POWER

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"The Power Man"

By Berton Braley

Beyond the "utmost purple rim"
You're certain to discover him,
All khaki-clad and lean and brown
And eager for the news of town,
But having chiefly on his mind
The keen desire to seek and find
A head of water that will do
To hitch a bunch of turbines to.

You run across the "power man"
In Arkansaw or Martaban,
Or clad in true explorer's style
And seeking sources of the Nile;
His stubborn aim, his constant dream
Is hitching up some roaring stream
And getting from its rush and roar
Ten thousand horsepower—maybe more,
Where nary horsepower was before!

He's somewhat lacking in romance
A waterfall he views askance
No matter how or where it's placed
He says—"There's power gone to waste
One hundred thousand h.p. loose
Which should be put to some good use.
Not lost in spray and roar."
A torrent tumbling o'er the brim
Is wasted energy to him,
And it is nothing more.

He breaks the trail through palm and pine
For power house and railroad line,
And on his footsteps cities press
And sweep away the wilderness,
But he goes on and on and on
Toward the sunset or the dawn
With mind and heart and soul intent
On harnessing a continent,
By turning every stream he can
To power for the use of man.
One single thought is on his mind
The keen desire to seek and find
A head of water that will do
To hitch a bunch of turbines to.

Lentz Engines in Baltimore Office Building

By Warren O. Rogers

SYNOPSIS—Power plant of the best office building in Baltimore, Md. Three Lentz poppet-valve engines supply power for the building service. The power plant also consists of elevator pumps, vacuum-cleaning apparatus, an absorption refrigerating system, also pumps for hot- and cold-water and fire service.

The new fireproof office building of the Maryland Casualty Co., Baltimore, Md., is pronounced the best equipped and most beautiful building in the city. It was decided to erect a new office building about a year prior to the great Baltimore fire in 1904, and work was begun

Fig. 1. Home Office Building of the Maryland Casualty Co.

immediately after the fire, with the result that the building shown in Fig. 1 is now the home of the company. The original building was three stories high, later two stories more were added to it and in 1911 the addition shown by the tower was constructed.

The building is located in the heart of the city with a frontage of 100 ft. on Baltimore St. The tower is 41 ft. square and rises to an observation platform 230 ft. above the street level. The height of the highest point, the crow's nest, is 349 ft. The tower is 18 stories high.

All mechanical equipment is in the basement and represents the latest design of power-plant apparatus. Owing to the restricted ground area considerable forethought was necessary in order to install the power plant and mechanical equipment required, and at the same time keep down the first cost and subsequent maintenance costs.

Engine Room

In the engine room, Fig. 2, are three poppet, four-valve engines having 12x18-, 13x18- and 16x21-in. cylinders respectively. These engines are directly connected to 50,- 75- and 125-kw., 125-250-volt, compound-wound, interpole direct-current generators.

A comprehensive idea of the finish of the plant is obtained from Fig. 2. The engines are placed on white glazed brick. The floor is of tile. The walls and ceiling are painted white with a dark-green wainscoting. All paint work is varnished, which facilitates greatly in keeping the room clean as this finish permits of washing. All machinery is painted a maroon color and tastily striped.

So quietly do the engines run that one is reminded of the sound of a new sewing machine. The three sizes of units give a flexible power plant and permit of operating the engines at their most economical loads. At the time of this writing one unit is sufficient to carry the load of the entire building. As the load increases with shorter days an additional unit can be started up to take care of it, the size of units being operated depending upon the load.

Boiler Room

Steam is supplied to the engines, pumps, etc., from three 150-hp. water-tube boilers, Fig. 3, fitted with superheaters designed for a pressure of 180 lb. of steam. The working pressure is 140 lb. The superheaters are damper regulated and deliver steam at a temperature of 100 deg. superheat. The boilers depart slightly from the standard design, as it was necessary to place them in a certain available space, somewhat restricted in width. Each boiler contains 1480 sq.ft. of heating surface. The furnaces are flush front and fitted with mechanical stokers. The size of these furnaces is 4½x6 ft., but when installed they were so arranged that the actual grate area is 4½x5 ft., thus making a grate area commonly used with a 125-hp. boiler. These furnaces are guaranteed to burn sufficient fuel to develop at least 35 per cent. more than the boiler rating. The stokers are operated by a stoker engine, which is hand regulated.

Each boiler has 83 tubes 3½-in. by 18-ft. long and one drum 36 in. in diameter. There is a soot-blower system attached to each boiler which is included as part of the boiler equipment. The furnace draft is regulated by a damper in the smoke flue and is controlled by a damper regulator. The steam gages are of the illuminated type, using red incandescent lamps, which makes an easy color by which to read the steam pressures indicated. Drop lights properly shielded illuminate the water glasses.

A receiver for the returns is located in the boiler room, also the feed-water heaters, two 6 and 4 by 6-in. boiler-feed pumps, coal-weighing outfit and hydraulic ash lift. Coal is delivered from the street surface to a coal hopper, arranged under the inlet opening in the street. It is then weighed and dumped into a coal bin below through sliding gates in the bottom of the hopper. These gates are operated by a lever from the boiler room. The floor and walls of the boiler room are of concrete. The walls are painted pea green with a marine-green wainscoting.

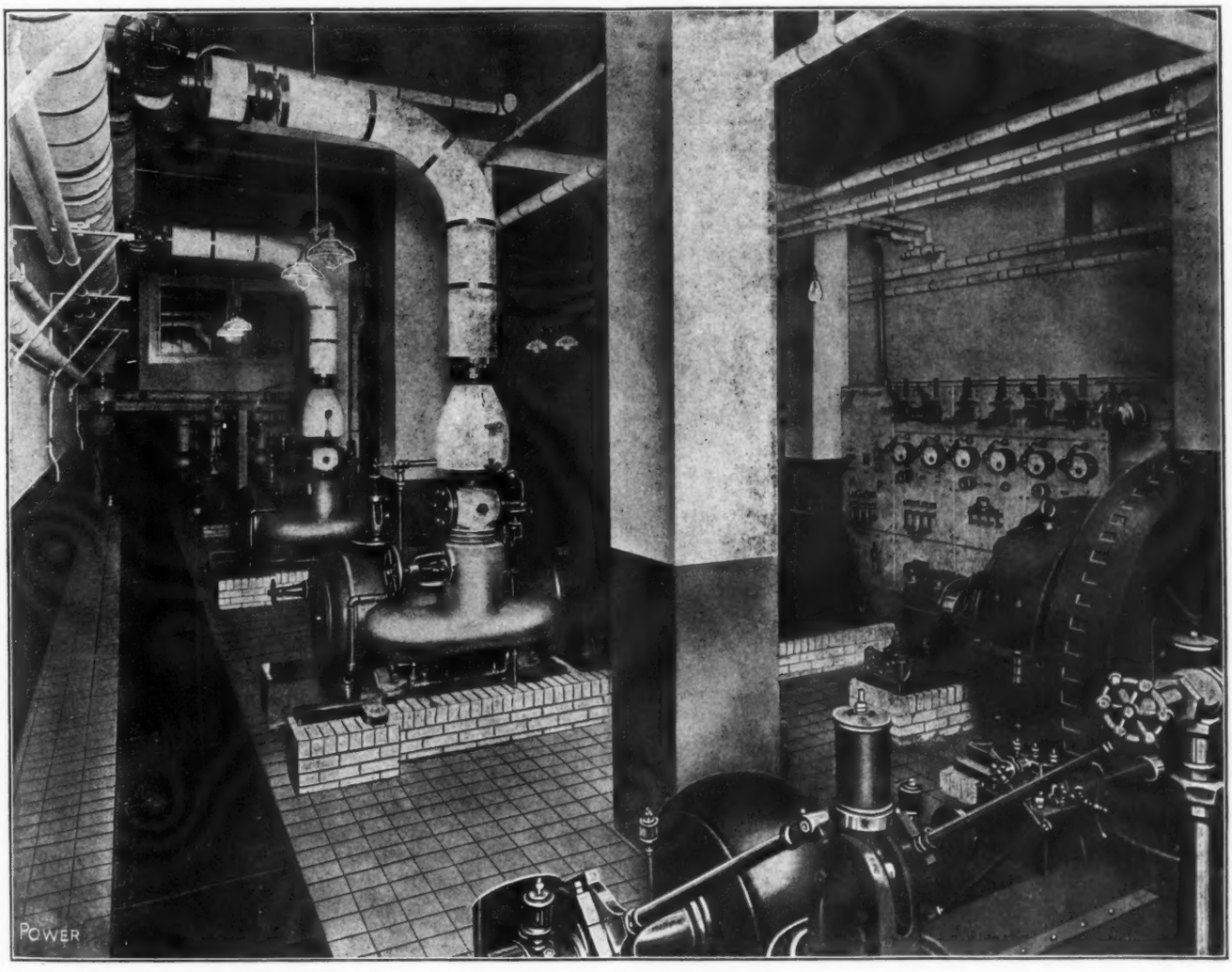

FIG. 2. THREE LENTZ POPPET-VALVE ENGINES

The fireman is furnished with a toilet in one corner of the boiler room.

Each boiler steam drum is fitted with a blow-down pipe as is also the mud drum, both being fitted with a blowoff valve. These two pipes are connected to a main blowoff pipe, which is fitted with a third blowoff pipe.

STEAM MAINS

There are two steam mains from the boilers to the engines and auxiliary units. One is 4 in. in diameter and under ordinary conditions supplies steam to the 75-hp. engine, pumps, etc.; the other is an 8-in. main and supplies the other two engines. Bypass connections, however, make it possible to cut out either line and still operate the engines and pumps. The small unit is piped to both mains. All piping is suspended from the sidewall upon brackets, as shown in Fig. 2, and is protected by suitable pipe covering.

At the center of the engine room, which is 144 ft. long and 30 ft. wide, are two 8 and 10 by 12-in. vacuum pumps, used in connection with the heating system.

For fire protection there is an Underwriters Standard duplex fire pump, size 16 and 9 by 12 in., with a capacity of 750 gal. per min. at 70 r.p.m. It is connected to a 5-in. hose standpipe which extends to the eighteenth story. From this standpipe there is a 2½-in. fire hose connection on each floor. The two 5¼x3½x5-in. cold-water house pumps are also connected to the standpipe and can be used on the fire system if occasion arises.

A view of the elevator pumps and a portion of the refrigerating system is shown in Fig. 4. Elevator service is provided for the building by five hydraulic plunger passenger elevators, one of which is a combination passenger and freight car, two of the elevators run to the fifth floor only, which is the height of the main building. The other three elevators provide express service for the tower floors. They have the longest run of any plunger elevators in Baltimore.

The pumping plant for the elevator service consists of two 12, 18 and 11 by 18-in. compound, piston-valve,

duplex, outside end-packed plunger pumps, one of which is used for regular service and the other for relay. There is also a small 5¼ and 3½ by 5-in. piston-valve, duplex, outside-end-packed plunger pump for lifting safes and other heavy loads. The 9½ and 8 by 10-in. air pump is of the water-jacketed type. The pressure and discharge tanks are constructed of ¾-in. steel designed for 175 lb. pressure per sq.in. Each is of 7500 gal. capacity, the

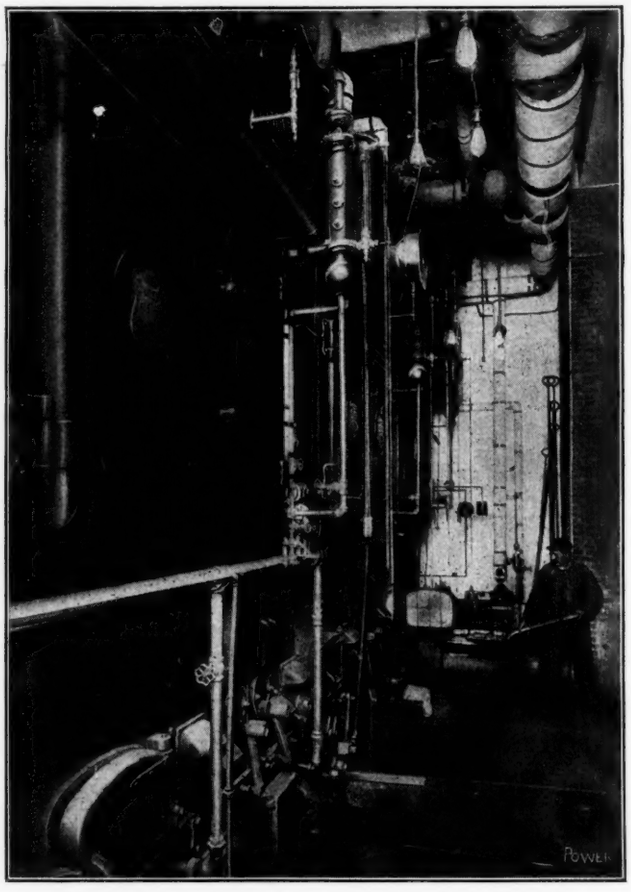

FIG. 3. FIRING FLOOR IN BOILER ROOM

pressure tank carries a pressure of 150 lb. The seams are of the quadruple-riveted, double-strap, butt-joint type.

A 10-ton absorption refrigeration system furnishes iced drinking water throughout the building and also cools the refrigerating chest in the kitchen on the seventeenth floor. A complete system for vacuum cleaning has also been installed, with all the outlets, brushes and other

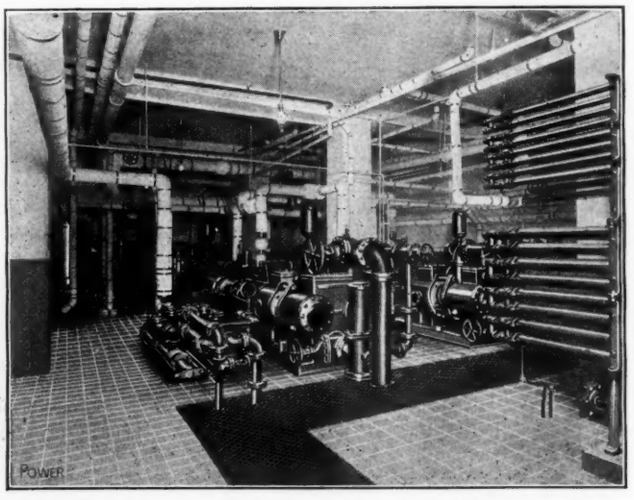

FIG. 4. ELEVATOR PUMPS AND PARTIAL VIEW OF REFRIGERATOR SYSTEM

paraphernalia necessary for an efficient system. A 15-hp., 230-volt motor running at 3400 r.p.m. is directly connected to a turbine vacuum cleaner.

SWITCHBOARD

The main switchboard, 24 ft. long and 6 ft. 8 in. high, is made in nine panels of blue Vermont marble. There is the usual power panel for each generator and one main distributing panel. The other panels are for controlling the various circuits throughout the building. In addition to the usual instruments there are three wattmeters and one special graphite wattmeter.

Attached to the switchboard is a pilot clock which operates in conjunction with the tower clock and shows whether the latter is running ahead or behind, thus permitting of regulating the clock without leaving the engine room.

The building is heated by a modern vacuum-return system, exhaust steam being used during ordinary cold weather, but with severe cold it is necessary to help out with live steam, as the low steam consumption of the engines does not supply enough exhaust steam to heat the building. All water used in the building for drinking, washing boilers and for other purposes is passed through a battery of water filters.

The design and installation of this plant was under the supervision of J. W. Rausch, manager of the boiler, flywheel and inspection departments of the company, to whom the author is indebted for photographs and data.

PRINCIPAL EQUIPMENT OF THE MARYLAND CASUALTY CO.'S NEW POWER PLANT.

No.	Equipment	Kind	Size	Operating Conditions	Manufacturer
1	Engine	Lentz	12x18"	Main unit, 75 hp., 200 r.p.m., 140 lb. steam	Erie City Iron Works
1	Engine	Lentz	13x18"	Main unit, 115 hp., 225 r.p.m., 140 lb. steam	Erie City Iron Works
1	Engine	Lentz	16x21"	Main unit, 190 hp., 200 r.p.m., 140 lb. steam	Erie City Iron Works
1	Generator	Direct current	50 kw	Main unit, 125-250 volt, 200 r.p.m.	Westinghouse Elec. & Mfg. Co.
1	Generator	Direct current	75 kw	Main unit, 125-250 volt, 225 r.p.m.	Westinghouse Elec. & Mfg. Co.
1	Generator	Direct current	125 kw	Main unit, 125-250 volt, 200 r.p.m.	Westinghouse Elec. & Mfg. Co.
3	Boilers	Water tube	150 hp. 1480 sq.ft. h.s.	Main units, 140 lb. steam superheat 100 deg.	Heine Safety Boiler Co.
3	Stokers	Murphy	4½x5 ft.	Boiler furnaces; flush fronts	Murphy Iron Works
3	Blowers	Bayer		Blowing boiler tubes	Bayer Soot Blower Co.
1	Regulator	Spencer		Damper control	Spencer Regulator Co.
1	Scale	Hopper		Weighing coal	Fairbanks Co.
2	Pumps	Duplex	6x4x6"	Boiler feed	Epping-Carpenter Co.
2	Pumps	Duplex	16x9x12"	Heating system	
1	Pump	Duplex	8x10x2"	Fire system	Buffalo Steam Pump Co.
2	Pumps	Duplex	5½x3½x5"	Cold water house service	Epping-Carpenter Co.
5	Elevators	Plunger		Passenger and freight	Standard Plunger Elevator Co.
2	Pumps	Duplex	12x18x11x18"	Elevator service	Epping-Carpenter Co.
1	Pump	Duplex	9x5x10"	Elevator service	Epping-Carpenter Co.
1	Pump	Water jacketed	9½x8x10"	Elevator system	Westinghouse Air Brake Co.
1	Refrigeration system	Absorption	10 ton	House and kitchen	Carbondale Machine Co.
1	Motor	Direct current	15 hp.	Vacuum cleaner motor, 230 volts, 3400 r.p.m.	Westinghouse Elec. & Mfg. Co.
1	Cleaner	Turbine		House vacuum cleaner	Spencer Turbine Cleaner Co.
1	Switchboard	Marble		Nine panel	Westinghouse Elec. & Mfg. Co.
1	Filter system	Battery		House water filter	Loomis-Manning Filter Co.

Barometric Condenser Piping

By B. S. Nelson

SYNOPSIS—Directions are given for properly piping a barometric condenser for reciprocating engines. There should be two strainers in parallel on the injection pipe.

The barometric condenser in which the vacuum is produced and maintained by the fall of a column of water in the tail pipe is so simple and satisfactory when properly installed and operated, that for cases where a very high vacuum is not essential it seems strange that it is not more universally used.

In irrigation plants the conditions are particularly favorable for a barometric condenser, as the load is uniform for long periods, varying only with the stage of the bayou or intake from which the pumps take water. The main units are usually driven by cross-compound engines where a vacuum of 27 or 28½ in. is as high as is necessary for good economy, especially since the injection water is usually warm, around 80 deg. F., for all pumping is done in the summer months. Then, again, with lifts which are usually in the neighborhood of 20 to 30 ft., it is possible to get sufficient siphon action from the discharge flume to provide injection water without the use of a small pump; in other words, the main pump, with its high economy, pumps the cooling water instead of a small wasteful auxiliary. Fig. 1 shows a typical barometric-condenser installation in an irrigation plant.

It is well known that without proper precautions in designing the piping the condenser becomes a source of danger, due to possibility of flooding the engine cylinder when starting up or running on very light loads. The

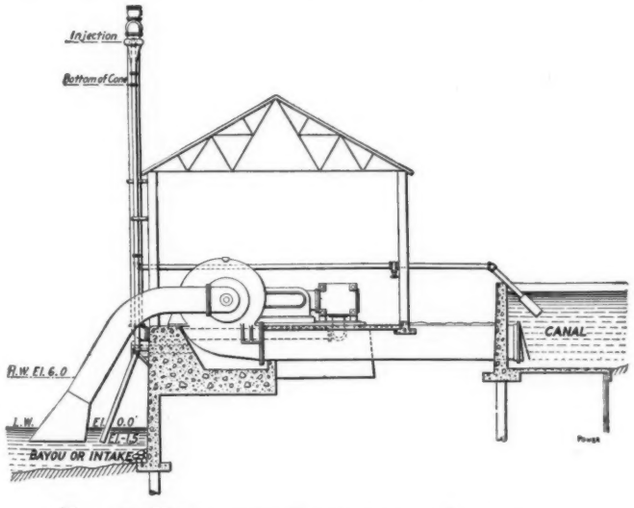

Fig. 1. Elevation, Barometric Condenser Installation

writer's experience has proved that the piping arrangement shown in Fig. 2 is excellent in practice where a spirojector is used. The size of the main pipes and the height of the cone above the overflow are not shown in the drawing. It is good practice to run the tail pipe directly into the intake instead of using a hotwell with overflow.

It is advisable to so place the condenser that the bottom flange of the cone is 34 ft. above the high-water line in the intake, or if a hotwell is used, above the overflow which allows the height of the condenser as leeway, to prevent possible flooding. Theoretically, 34 ft. from injection to overflow is enough, but the water in the tail pipe contains air; therefore it is lighter than solid water.

It is best to use the sizes of injection and tail pipes recommended by builders for each particular condition, and they should never be smaller than companion flanges

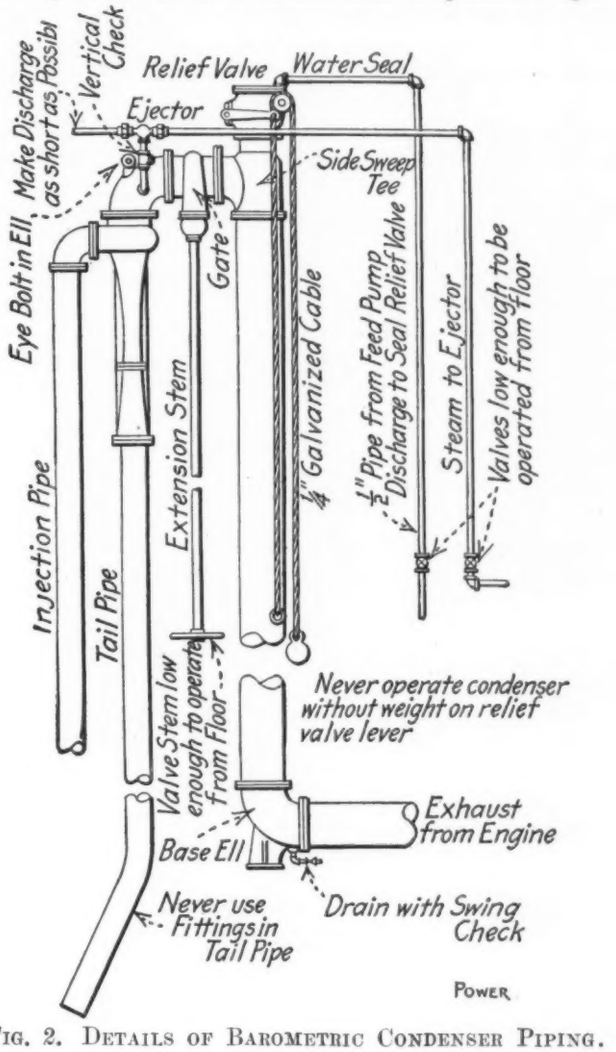

Fig. 2. Details of Barometric Condenser Piping.

call for, provided the condenser used is not too big for its work. Then reduction should be made with tapered reducers, not with bushings. The injection pipe should be provided with a strainer of ample size, preferably two in parallel, and also a valve to control the water-supply.

Referring to Fig. 2, the exhaust pipe should have a slight fall toward the riser and at the lowest point of the ell at the riser, which should be a base ell; an automatic drain, consisting of a 1¼-in. check valve opening out, should be installed without a valve between it and the air. At the top of the exhaust riser is a reducing tee, on the small end of which is connected an automatic relief valve. This can be one or two pipe sizes smaller than the main exhaust, due to the smaller volume of steam at atmospheric pressure; that is, a 14-in. exhaust

would take a 12-in. relief, a 10-in. exhaust an 8-in. relief, etc.; and should always be of the closed type, so it can be water-sealed by a ½-in. pipe as shown.

The relief valve should have a wire cable to the floor for opening by hand; this cable should be weighed with a ball equal to 5-in. vacuum to prevent chattering on the seat which will quickly ruin the valve.

For example, a 10-in. valve should have a pressure on the disk roughly equal to 190 lb., which would probably mean a smaller weight, as the disk is held by a longer lever arm to which the cable is attached. On the tee outlet there should be a gate valve, then the condenser elbow. It has been found most satisfactory to point the stem of the valve down and use an extension stem to operate it from the floor. Many installations omit this valve, which is so essential both for starting up properly and for repairing the condenser while the engine is running.

The illustration shows a small ejector for priming the condenser, which is used in cases where the condenser siphons its water to start it flowing. Where a pump is used to supply water this is not necessary.

In starting the unit, the engine is first started with the gate valve to the condenser shut, and is so brought up to speed. In the meanwhile, the condenser is being primed by the ejector, or the supply pumps started, and when the water starts to flow, the gate valve to the exhaust is slowly opened. Then the valve in the injection line is manipulated until the best vacuum is attained, which is usually with the valve partly closed.

In conclusion, it is well to mention that, a good strainer should be used. The main trouble with barometric condensers is due to air leaks at the flanges, relief valve, or low-pressure stuffing-boxes. It is well to test these joints with a candle occasionally.

For supporting small condensers up to about 10 in. or 12 in., it has been found satisfactory to use a base ell on the exhaust and injection risers, and let the condenser rest on them, the whole outfit being braced to the building wall by A-braces. For larger condensers, there must be either a tripod for the base flange of the tail pipe or a special fitting with lugs may be fastened to the tail pipe. In no case should a base ell, or any other sort, be used in the tail pipe. If the pipe must have angles use bends.

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Boiler Attachments—II.

By J. E. Terman

SYNOPSIS—The proper location and pipe connection of the steam-gage are discussed, also the correct and incorrect connection of the blowoff pipe and valves. The application of the surface blowoff is also set forth.

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The only boiler attachment that can be safely connected to the pipe connecting the water column to the steam space of the boiler is the steam-gage, since there is no flow of steam required for its operation. No valve should be allowed between the steam gage and the boiler it is to serve, except the small cock used immediately below the gage. The handles on these cocks always show at a glance, whether they are opened or closed. The foregoing requirements do not apply to steam-gages used on the steam main, or in the engine room, but only to the individual gages on each boiler. Every boiler should be equipped with an individual steam-gage, except in case of two or more boilers connected by steam and mud drums, so that they are necessarily always operated together as a single unit. In this case, a single steam-gage connected to one boiler of the battery is sufficient.

The modern steam-gage is dependent on the action under pressure of a Bourdon spring to produce registrations. This spring consists of a flattened tube bent in the form of a coil, which tends to straighten when subjected to internal pressure. The Bourdon spring is affected by temperature as well as pressure, so it is necessary to protect a gage from any serious changes of temperature, if its registrations are to be correct.

To prevent the steam gaining access to the spring, the gage must be arranged so that a water pocket will be formed in the piping connecting it to the boiler. Where small, light gages are used, which are supported entirely by the connecting pipe, it is usual to provide this pocket by turning a goose neck in the pipe, as shown in Fig. 7.

Where the gage is heavy and is fastened to some portion of the boiler front or setting, or to the building, the piping is usually arranged to drop down toward the gage from some higher point, and thus form a trap for collecting sufficient condensation to protect the gage spring. External heat will affect the spring the same as if applied internally, therefore the gage should not be fastened directly to any surface that is likely to become unreasonably hot, such as the breeching or the portion of the front above the tube doors. Where it seems advisable to fasten a steam-gage to such parts, it should be thoroughly insulated with sheet asbestos or similar material, and in addition an air space of an inch or two should be left between the gage-case and the surface to which it is attached, to permit the free circulation of air.

Most gages have the operating mechanism so attached to the case that a strain tending to warp the case will affect the accuracy of the indications. Therefore, the surface on which the gage is fastened should be flat, or conform to the surface of the back of the gage-case; it is also well not to tighten up too much on the screws or bolts used to hold the gage in place.

On account of the steam-gage being usually attached to the steam space (by law in Massachusetts), there is no tendency for scale produced by impurities in the feed water to form in these connections; but rust scale often forms in them, and due to their small size, they readily become stopped up. A number of very serious explosions have been caused by the stoppage of the connection to the steam-gage, and it is the safest to have all small piping used to connect the gage to the boiler or to the water-column piping, of brass; and if these connections are of any considerable length, their size should be increased to ⅜ or ½ in., instead of the ¼-in. size generally employed.

Since the location of a steam-gage is not very definitely fixed by its connection to the boiler, a location should be chosen that will make its indications easily seen from any part of the firing floor, and such that there is no likelihood of a mistake being made as to which boiler the gage is attached. A steam-gage should be tested periodically to determine its accuracy, and no power plant, no matter how small, should depend entirely on the indications of a single gage.

Blowoff Pipe and Connections

The blowoff connection is an important attachment. A

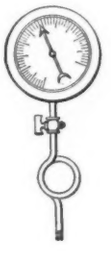

Fig. 7. Steam Gage Connection

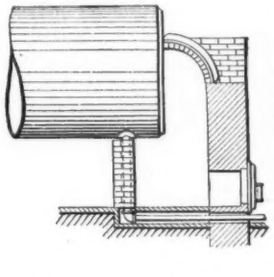

Fig. 8. Proper Blowoff

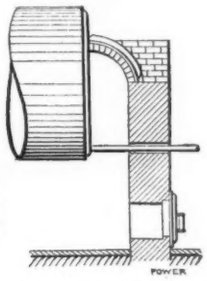

Fig. 9. Improper Connections

general idea is that the chief function of the blowoff connection is to remove scale and deposit from the boiler. A little reasoning will show the fallacy of presuming that this attachment can possibly accomplish such a purpose effectively.

If the reader has ever watched an open tank empty through a bottom connection, he will have noted that only the mud and dirt on the bottom immediately over the opening are removed at first, and that the main part

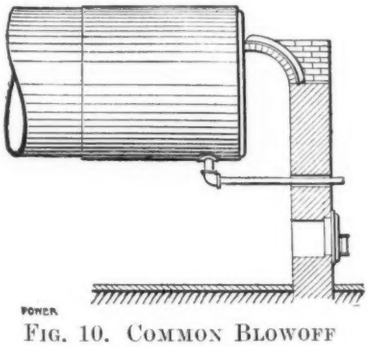

Fig. 10. Common Blowoff Connection

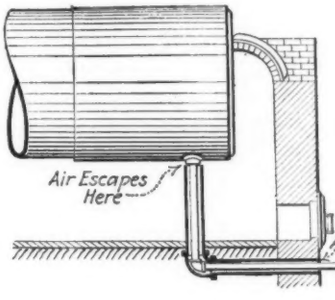

Fig. 11. A Practical Blowoff Pipe

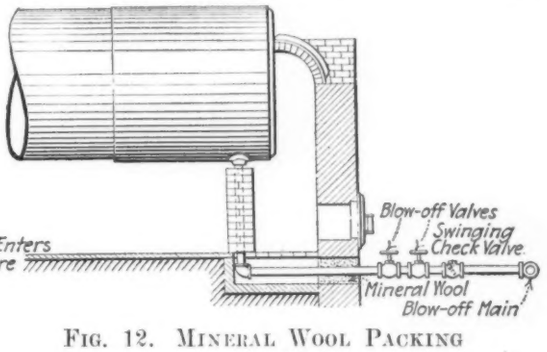

Fig. 12. Mineral Wool Packing around Pipe

of the discharged water is drawn from above the bottom, rather than from along the bottom. It is the same in blowing off a boiler; opening the blowoff for a short interval only removes the mud and scale immediately adjacent to the blowoff connection, or suspended in the water above it.

The principal function of the blowoff connection is to remove water from the boiler that has become concentrated or heavily charged with the various salts contained in the feed water, and thus permit the dilution of the water remaining in the boiler by the addition of fresh water from the feed supply. It is in this way that scale is prevented from forming in the boiler, by frequent use of the blowoff connection, and not by the actual removal of scale that has been formed. The blowoff connection is also necessary to permit the complete draining of the boiler for washing out or scaling, or for repair. The blowoff for a horizontal-tubular boiler should always be located in the bottom of the shell, about a foot in front of the rear head seam, as illustrated in Fig. 8. This location is preferred to any other, because it permits the complete drainage of the shell, and also that the blowoff pipe is more easily protected from the furnace heat at this point. It is not infrequent that a blowoff pipe is connected to the rear head as illustrated in Fig. 9, but this is poor practice. This connection does not permit the complete draining of the boiler, and this alone is sufficient to absolutely condemn it.

The blowoff pipe is often arranged as illustrated in Fig. 10, but this is not usually a satisfactory arrangement. If an elbow is used, as shown, it is difficult to protect it from the heat, and a fitting is more liable to suffer from overheating in such a location than the pipe. This objection is partially overcome by using a piece of bent pipe in place of the elbow, but this requires that a pipe coupling be placed inside the setting wall, for, since the blowoff is fitted up after the boiler has been set, the bent pipe must be short enough to turn inside the setting, so as to permit its being screwed into the flange on the boiler shell. A horizontal section of blowoff pipe in the fire is more difficult to protect from the heat than a vertical section similarly located, and there is also the added difficulty that deposit is more liable to lodge in the heated portion of the pipe in this position, and make its protection from the heat more important.

The best arrangement for the blowoff pipe is illustrated in Fig. 8, where it is run directly from the shell to a point below the paving of the rear combustion chamber, and the horizontal portion run through a brick trough, the top of this trough being formed of loose bricks that may be readily removed for inspecting the condition of the pipe. The vertical portion of such a blowoff pipe should be protected from the direct impingement of the flame from the furnace, by a V-shaped pier of firebrick, placed immediately in front of the pipe. This arrangement is best, because it does not in any way interfere with the thorough examination of the pipe, and also affords ample protection from the heat. A protection that is very effective, but which does not permit a ready examination of the pipe, is obtained by slipping a piece of larger-sized pipe over the vertical section of the blowoff, as illustrated in Fig. 11. To render this form of protection fairly durable, it should be arranged so that a small quantity of air will be admitted to the bottom end and flow upward between the two pipes.

Blow-off pipes are often protected by winding asbestos rope around them; which is fairly satisfactory, but it is hard to keep in place, especially if the protected portion of the pipe is located so that it is liable to be struck with the cleaning tools. Asbestos rope is possibly the best, as well as the most easily applied form of protection for use on connections such as shown in Figs. 9 and 10.

Where practical, the horizontal section of the blowoff pipe should be a sufficient distance above the floor level, to permit a suitable arrangement of the blowoff main and valves outside the setting walls. This requires, if the arrangement is to be as shown in Fig. 8, that the pavement in the combustion chamber be considerably above the boiler-room floor level. This arrangement also contributes toward making it easy to remove the ashes from this portion of the setting, if ample room is available behind the boiler setting. All pipe and fittings to the blowoff connection should be extra heavy, regardless of the pressure carried, for this portion of the boiler equipment is liable to deteriorate very rapidly from various causes and the strains that may be brought upon it due to operation of the blowoff valve or cock, are out of all proportion to the steam pressure carried.

It is an important matter to provide ample room around a blowoff connection, to prevent strains that may be produced by the pipe coming in contact with the setting walls, due to the expansion of the boiler or pipe. To prevent leakage of air where the pipe passes through the setting wall, the space left for expansion may be lightly packed with mineral wool or some other heat-resisting material, as shown in Fig. 12, that will offer only slight resistance to the free movement of the pipe. On the horizontal-tubular type of boiler, the blowoff pipe is usually subjected to maximum movement at the point where it passes through the rear setting wall, due to the expansion of the boiler, as well as the expansion of the portion of the pipe contained in the setting, and it is also liable to considerable movement at this point, due to the expansion of the piping outside the setting, when in the act of blowing down a boiler. The arrangement of the blowoff piping outside the boiler setting where the pipes from a number of boilers are connected to a single blowoff main, is important, on account of the possibility of strains due to expansion.

The importance of this may be better appreciated when it is considered that a change in temperature of 150 deg., F., in the piping, when blowing off boilers, is not unusual. This change in temperature on 100 ft. of pipe would mean a change in length of about one and one-eighth inches. The length of pipe just considered would be about the amount required at the rear of a battery of ten 72-in. diameter boilers. If a main of this description were held rigidly at one end, the branch connections to the boilers at the other end would have to be flexible enough to care for this amount of movement without unduly straining the fittings, or causing the pipe to come in contact with the setting walls. It is usually best to have the blowoff main rest on the floor of the boiler room, if it is of concrete, and not fastened rigidly at any point but allowed to move freely. If on account of vibration, or to care for the thrust of some portion of the pipe that is extended beyond the boiler setting, it is thought advisable to anchor it, such anchorage is best applied near the center of the battery of boilers. This divides the movement due to expansion in half and materially lessens the strains that may be brought on the fittings.

Blowoff Fittings

So much trouble has been experienced with the use of blowoff valves and cocks, that nearly every one connected with the operation of steam boilers and who has an inventive turn of mind, has tried a hand at solving the problem. The number of different kinds of valves and cocks used for the purpose is legion. A claim to some special virtue is usually made for each type of valve or cock; either some feature regarding its action in use or a peculiar form of construction that is supposed to render it immune to the usual forms of trouble experienced with this kind of apparatus.

The best arrangement for controlling a blowoff connection is to equip it with double valves or a valve and a cock of reliable make, using one to perform the actual act of opening the connection to blow down, and for stopping the flow; opening the other before and closing it after the first.

In this way, the seat of one valve is protected from wear, which is usually the result of the filing action pro-

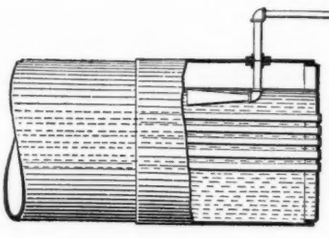

Fig. 13. Single-End Skimmer

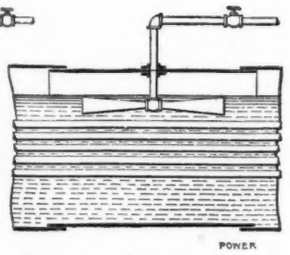

Fig. 14. Double-End Skimmer

duced by the escape of sand and other substances carried at high velocity across the seats, and especially through the restricted passages, produced at the instant of opening and closing the valves. Two valves used in the manner described require less attention than a single valve, because the protected one can be depended on to remain tight much longer than if one valve were used, and until this valve has begun to leak, no repair such as reseating, need be undertaken. Another feature that renders double valves desirable is that, when scale or other material blown from the boiler happens to lodge in one or the other so that it is rendered inoperative, as is frequently the case, the other valve is ready for use.

A globe valve is not suitable for use on a blowoff, because the tortuous passage through it is liable to produce stoppage by the lodgment of particles of scale; the cutting action produced by grit on the seat is also severe. In using a cock, or any quick-closing type of valve on a blowoff connection, serious strain may be produced in the pipe by water-hammer action in operating too quickly and on this account the size of pipe from the boiler to the valve or cock should be limited to 2½ in. Sizes below 1½ in. are liable to clog with scale or mud, so that the smallest boiler should be equipped with a blowoff of at least this size, if practicable. This leaves the small range in sizes, from 1½ to 2½ in., suitable for this purpose.

One of the objections to the use of a cock, especially of the common brass-plug cock style, is that the plug

heats up more rapidly than the body when blowing off, and is liable to seize fast, due to expansion, after being opened for a short time, and is thus prevented from closing. Engineers caught in such a predicament, with only one device on the blowoff connection, have attempted to loosen the plug by driving it up from the bottom. Such treatment is exceedingly dangerous as the fastening may give way, and the plug be blown out and the operator scalded. The Massachusetts rules very wisely provide that the plug on a cock must be held in place by a guard or gland, which is intended to prevent such an accident.

It is common practice to connect the blowoffs from two or more boilers into a common main pipe, to be led out of the boiler room to a suitable place for discharge. This arrangement has been responsible for scalding many boiler cleaners and repair men or others required to work inside idle boilers. In a plant containing many boilers a few are usually idle at all times for repairs or cleaning, and when a boiler is blown off into such a line, unless the blowoff valves on the idle boilers are closed, the pressure produced in the main blowoff pipe will force scalding water and steam back into the idle boilers. An accident of this kind is usually due to carelessness on the part of those working inside, in failing to see that the valves on the idle boilers were not closed, or else by someone tampering with the valves. There is one certain remedy that will prevent this class of accident; have the blowoff from each boiler separate and distinct, throughout its entire length. In the case of large batteries of boilers, and especially where the discharge point is at all remote from the boiler house, as is usually the case, this remedy will be expensive, and it is likely that the management of the plant will not consent to the necessary outlay. In such case, the writer would suggest a remedy, that while, as far as his experience goes, has never been used, would seem to be perfectly feasible. This is to equip the individual blowoff pipe from each boiler with a swinging-check valve, as illustrated in Fig. 12. This would prevent any sudden rush of steam or water back into a boiler from the blowoff main, and would not interfere to any serious degree with the outflow of water when blowing off, especially if the check valve was the next pipe size above that of the blowoff pipe from the boiler.

A point about the arrangement of blowoff piping, often overlooked in installation, that is liable to lead to a serious accident is seeing that the system of pipes drains thoroughly by gravity to the discharge point. A pipe that remains partly filled with water, which becomes cold between the times of operating the valves, is liable to cause severe water-hammer in the pipes during the act of blowing down. This action may break the fittings or the bonnets of the blowoff valves and probably scald the operator.

The blowoff connections on the various types of water-tube boilers are usually arranged at the lowest point, so as to drain the boiler as completely as possible, for the purpose of cleaning or repair. In some sections it is customary to have the blowoff pipe from the boiler of large size, 4 to 6 in. in diameter, and in the City of Chicago this construction is made compulsory by the municipal-boiler laws, the size being reduced at the blowoff valve. There seems to be no good reason for this kind of equipment, and there are objections. A large connection is placed on the boiler at a point which is exposed to high temperature, the large pipe renders the consequences of a rupture from any cause more serious and the danger of the pipe pulling apart at the threaded connections is increased.

Surface Blowoff

With feed waters containing salts, which tend to form light, foamy, floating deposits on the surface of the water, a surface blowoff is sometimes efficient in preventing foaming, a trouble that is liable to occur with this kind of feed water. The difficulty about the installation of this piece of apparatus is to get it to cover enough surface to be effective, and still not interfere too much with accessibility for the purpose of cleaning or repair. The usual arrangement is to have a flattened cone of thin sheet iron placed so that it will be central with the waterline. Fig. 13 shows the arrangement as usually used. Sometimes the funnel is made double-ended, as shown in Fig. 14, and is placed on the waterline at an equal distance from the two tube sheets, with the open ends pointing toward the front and rear heads of the boiler.

Power Development at the Panama-Pacific Exposition

A conspicuous feature of the Department of Machinery display at the Panama-Pacific International Exposition will be the latest methods of power development. The exposition is to be contemporaneous and not historical; therefore the evolution of the steam engine will play but a very small part.

The exhibits will contain a number of Diesel engines, operating upon California crude oils, which form such a large part of the resources of the state. The development of this type of motor has been somewhat checked in the past year by increasing prices of the fuel oil used. In the original conception of the Diesel engine it was anticipated that pulverized coal could be used as the fuel in the cylinder of the engine in the same manner as the liquid fuel is now used, but it was found that the residual ash from the solid fuel made this impossible. There is, however, being tried out in England a 100-hp. engine in which powdered coal fed by worm screw through tubular openings in the cylinder head is heated by the exhaust gases and the air supply for the engine drawn through the coal in such a way as to form producer gas, which is utilized in the engine as it would be in the ordinary gas engines. The range of fuel with which such an engine can be operated is much wider than that of the Diesel type and it is expected that among the exhibits at the exposition it may have its place and will represent practically the last word in power production.

The authorities have already been promised an exhibit of the Humphrey gas pump, which is a unique form of internal-combustion motor. In this pump the mixture of gaseous fuel and air contained in one end of a U-shaped tube is exploded by any of the usual methods of ignition, and the expansive force so produced forces the water out at the other end, where there is also a chamber within which the air is compressed by the water.

After the expansive force of the fuel charge is ex-

hausted the air compressed in this chamber sets up a return surge, which expels the burned gases and then swinging back with rhythmic impulse draws in a fresh charge of air and gas, as well as of water, which charge of air and fuel is compressed on the next return stroke and exploded when it reaches the point of highest compression, thus starting the cycle over again.

A pump of this type is being used today in London, having a pumping capacity of 50,000,000 gal. per day, and complete designs have been made for a German plant having 150,000,000 gal. capacity. This latter would be over four times the daily consumption of San Francisco.

This form of pump will probably find many applications other than that of pumping alone. It may be utilized for compressing air; and a proposition has been made in Germany to utilize it in power production by delivering the water which it discharges through a water-wheel directly connected to an electric generator. The combined efficiency thus obtained will be at least double that of the most improved form of steam plant.

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Conservation of Coal and Liquid Fuel

By Special Correspondent

SYNOPSIS—A résumé of the papers read at the eighty-third annual meeting of the British Association for the Advancement of Science, held at Birmingham, Eng., Sept. 10-17, 1913.

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The chief topic of practical interest to power-plant engineers that was dealt with at the recent Birmingham meeting of the British Association, was the more scientific use of solid, liquid and gaseous fuel, for the purpose of generating power or heat. A group of papers upon this most important subject was read in the chemistry and engineering sections of the association. Since the conditions in America today with regard to power generation from coal and oil, are similar to those existing in England, a résumé of the contents of these papers should prove of value.

After a general introduction, discussing the various prime movers for generating power and their defects, Professor Burstall in his paper on "Solid, Liquid and Gaseous Fuels" touched on the total remaining amounts of the various types of solid and liquid fuel available. The annual output of coal by the mines of the whole world was estimated to be about 1200 million tons—while that of crude oil was estimated at 50 million tons. Since it was doubtful if any large oil fields remained undiscovered, it followed that the supply of crude oil was totally inadequate to replace the solid fuel now used for power production. The artificial production of oil fuel ought, therefore, to be seriously taken in hand. Up to the present time coal has been gasified with the idea of producing the highest yield and volume of gas, but it is quite possible and practicable to alter the conditions of carbonization so as to obtain a high yield of fuel oils and other compounds of great value, including sulphate of ammonia. By the present methods of gasification, a modern gasworks will produce from every ton of coal between 11,500 and 12,500 cu.ft. of gas with a calorific value of 550 B.t.u. per cu.ft.; 10 gal. of tar; and 25 to 30 lb. of sulphate of ammonia.

The author thinks that the future of coal treatment in this and other countries will be in the decomposition of the fuel in closed retorts, under conditions which would make the yield of a standard illuminating gas the secondary consideration, and would elevate the yield of by-products into the chief one. It has long been known that the quantity and quality of the tar is largely influenced by the temperature at which the fuel is carbonized, the lower the temperature the better being the yield and composition of the tar oils. If the gas and tar are withdrawn from the retort immediately they are evolved, many of the tar oils (after distillation) can be employed for power generation in internal-combustion engines. These tar oils will yield on distillation, benzol, light oils of the pentane and hexane series; middle oils such as crysilic acid, and finally heavy oils of the anthracene series.

The author then sketched out the details of a large scheme of this kind for treating coal at the pit's mouth; the carbonization units of this scheme being of 2000 tons fuel capacity per day. The tar and gas would be taken by pipe lines to suitable points for their further treatment, the tar being subjected to fractional distillation in continuous stills, automatically worked, to obtain the various light and middle oils from it, before sale of the residuum as a liquid fuel, or for road-making purposes.

Such a works would produce from 120,000 to 140,000 gal. of tar per day; the recovery of byproducts from this large amount of tar would be regulated according to the relative market price of the various oils obtained.

The gas generated from the carbonizers would not be purified from sulphur, but would be used in its crude state in large 2000-hp. gas engines for the generation of electricity. This would be generated at high voltage, and would be distributed over a wide area from the generating plant at the pit's mouth.

The exhaust gases from the gas engines would then be chemically treated, in conjunction with the liquor from the ammonia plant, and both these constituents—the nitrogen and sulphur—of the raw fuel would be recovered in the form of ammonium sulphate.

The author admitted that, at present, this scheme was somewhat visionary, but hoped to see it realized within a reasonable time.

Professor Armstrong opened the proceedings in the chemistry section on Monday morning, Sept. 15, by emphasizing the great importance of the fuel question, and the need for prompt action if the fuel resources were to be wisely used. In his opinion legislation was certainly required at the present date, to render illegal the use of raw coal for heating purposes, either in private houses or in works and factories, since only in this way could any reform of the present methods of heating be carried through in reasonable time.

All coal would then be subjected to destructive distillation before its use, and this distillation would be carried

out under the scientific conditions required to obtain a maximum yield of all the valuable byproducts.

Finally the methods of using gas for heating purposes would also require to be reformed, and Professor Bone's method of obtaining remarkably high thermal efficiencies by flameless combustion would doubtless be one that would receive widely extended application in the near future.

Dr. George Beilby, of Glasgow, contributed a paper on the "Low Temperature Carbonization of Coals" to the same section. After considering the advantages offered by this method of treatment and discussing some of the causes of the failure of the "Coalite" system, the author gave an account of the practical progress made at the works of the Cassel Cyanide Co. in Glasgow, with the design of an improved retort and process for carrying out the low-temperature carbonization of solid fuel.

After numerous trials, extending over a period of four years, an apparatus had been designed which would coke 15 tons of coal per day, at a temperature between 750 and 840 deg. F. This apparatus was continuous in its system of working and would convert cheap noncoking small coal, either into a fuel suitable for gas-producer work, or into a smokeless fuel for domestic use, while at the same time enabling one to recover from the evolved gases all the valuable byproducts of the raw fuel. The thermal value of the gas obtained from the apparatus was high, namely, 850 B.t.u. per cu.ft.

In concluding his valuable paper, Doctor Beilby stated that the chief difficulties at present were due to the caking of the coal, and to the breaking down of the charge into coke no larger than the ordinary coke breeze. These were serious but not fatal defects. To render the coke after treatment in the carbonizers fit for household use, it was necessary to briquette it; for the gas-producer work the coke could be used exactly as it came from the carbonizing plant. The briquettes were manufactured by using 7 per cent. of pitch as binding material, and they were sold in Glasgow at present for household use at the rate of 20 shillings ($5) per ton. It was quite possible, however (as the apparatus and process were improved) that this price might be lowered, and it was not given as indicating the final value or price of the domestic fuel produced by the process.

Finally, the author stated that the really significant points in any successful process were covered by the economic and engineering questions: Can an outlet be found for large amounts of this low-temperature coke? and can a satisfactory apparatus be devised? The apparatus must be constructed in fairly large units; it must be automatic in working, and must operate with the smoothness and regularity of the best types of automatic stoking machinery, and with a minimum of manual labor or of skilled supervision. The gases and vapors from the distillation must also be carefully preserved from loss or damage, either through leakage of the gas outward, or leakage of air inward. The necessary heat must be so applied as to cause no deterioration of the material of which the apparatus was constructed, and the heating of the charge must be economic.

The author stated that he was not without hope that an apparatus would be designed, which would tempt the orthodox gas engineer to give low-temperature carbonization a serious trial on its merits.

Professor Bone, of London, followed Doctor Beilby with an account of the latest practice in the use of gaseous fuel, in the iron and steel industry. As Professor Bone is the patentee of the Boncourt or "flameless" combustion method of utilizing gas for heating purposes, his address was followed with much interest by a crowded audience. Discussing the relative costs of gas from various sources in the United Kingdom, he gave the following figures:

		Cost in cents per 1000 cu.ft.
1.	Coal gas, as made by an ordinary gasworks	24
2.	Water gas	8
3.	Producer gas, without ammonia recovery	3
4.	Producer gas, with ammonia recovery	2

The above represent the cost of production only. It is assumed in the case of Nos. 2, 3 and 4 that the producers work with a thermal efficiency of 70 to 75 per cent.; and the estimates are based on fuel costing $3.60 per ton, and coke realizing, when sold, $2.88 per ton.

With regard to the general question of heat utilization in iron and steel works, he predicted that at no very distant date, the need for a gas-producer plant in steel works would be nonexistent, and the furnaces would be heated, and the power generated, entirely by the waste gases from the blast furnaces and coke ovens. A modern blast furnace yields about 168,500 cu.ft. of gas per ton of iron produced. An output of 1000 tons of iron weekly represents, therefore, about 1,000,000 cu.ft. of gas per hour. This gas has a low calorific value; namely, 100 B.t.u. per cu.ft., and on this account after cleaning from dust, it forms an ideal gas for power-generation purposes.

The excess of blast-furnace gas not required for heating purposes, is now being employed extensively in modern iron and steel works for power generation, and at Seraing, in Belgium, where the greatest developments have occurred in this application of the waste gases, a 6500-hp. gas engine is now being erected as an addition to the existing generating plant. At this large works, the surplus gas from the blast furnaces is capable of generating 28,500 hp. continuously, at an efficiency of 28 per cent.

As regards the use of blast-furnace gas for heating purposes, at Skinningrove, in Yorkshire, the gas is enriched by admixture with coke-oven gases until it tests 130 B.t.u. per cu.ft., and this mixed gas is then employed for heating the Talbot and other steel-producing furnaces.

W. H. Patterson, of Liverpool, contributed a short paper on "The Improvements of Combustion Due to Blending and Chemically Treating Fuels." Tests were made on a marine boiler with two fuels, one marked A the other B. The laboratory calorific tests of these fuels gave the following values: A, 6524 cal.; B, 7351 cal.; while practical boiler trials gave the following evaporation: A, 8.87 lb. of water; B, 10.56 lb. of water per lb. of fuel. The fuels were then mixed in definite proportions, and this mixed fuel on practical trial in the boiler gave a much higher efficiency than the average of the above figures (9.71 lb.), the evaporative duty being nearly as high as that of fuel B alone.

Another remarkable effect was obtained by treating coal, while in a moist state, with chlorine gas. Not only was the heat efficiency increased and the ash diminished by this treatment, but the physical features of the coal appeared to undergo modification, and a bituminous coal

gained in this way some of the characteristics of a smokeless semi-anthracite fuel.

Papers upon "The Manufacture of Coal Gas," by Dr. H. G. Colman; by J. H. Yates on "Improvements in Gas Fires," by Dr. R. Lessing on "Smokeless Fuels and Coal Oils," and by Dr. R. V. Wheeler on "The Composition of Coal," were also contributed to this session. The most interesting statement contained in these four papers was that of Doctor Colman—that high-pressure coal gas (under 12 in. water pressure) was now being supplied through special mains in Sheffield and Birmingham for metallurgical purposes, and that a large number of manufacturers were employing this gas for melting and refining metals and alloys. The high-pressure gas in Birmingham was supplied at the same charge as ordinary coal gas, namely, at 32 to 36c. per 1000 cu.ft.

Doctor Wheeler gave details in his paper of a new method of separating raw coal into its two main classes of constituents, by aid of pyridine and chloroform. He also gave an account of the remarkable effects produced on photographic plates in the dark, by the resinous constituents of fuel. In the author's opinion this photographic method of examining a fuel might be used to guide one to a judgment concerning its caking and coking properties.

A Remarkable Maintained Economy Test

By A. D. Skinner

Tests for maintained economy are so uncommon in this country that the results of the tests made on two double-eccentric, single-valve, tandem-compound Skinner engines, after 14 months' service, will no doubt be of interest. The causes that contributed to this unusual test were peculiar. The Universal Caster & Foundry Co., of Newark, N. J., were considering various types of engine, and the selection finally narrowed down to a single-cylinder multi-valve engine and the aforesaid make of compound engine.

Two engines of different capacities were to be purchased, and, while the guarantees made for the compound engines were naturally lower, the price was $1503 higher. The purchasers were willing to pay the additional price if they could be convinced by a practical demonstration that the compound engines would fulfill the guarantees made for them, not only while the engines were new, but after they had been in operation for at least one year and without any refitting of valves.

These conditions were agreed to and at the end of a year an economy test, conducted in accordance with the American Society of Mechanical Engineers' code for steam-engine trials, was to be made on both engines, and under the direction of a consulting engineer appointed by the purchasers.

Both engines were allowed to run for 14 months, instead of 12, for the reason that it was not convenient for either the purchasers or the engine builders to make a test after the engines had been in operation the stated period, and in the meantime the valves had not been tampered with or adjusted. F. H. Ogden, a consulting engineer, of Newark, represented the purchasers, who also had other representatives present to check the results.

Inasmuch as it was necessary to conduct the test by weighing the water before it was fed to the boilers, unusual care was taken to insure its accuracy. A boiler and line-leakage test was made one month before the test on the engines, and a second leakage test was conducted on the same day on which the engine tests were made, the results of both leakage tests being almost identical. The water weights and levels in the boilers were checked during the engine tests at the end of each hour, and showed almost constant consumption, thereby verifying the final results. Water was fed to the boilers through injectors, the steam supply for which came from the boilers themselves. The water was weighed in barrels on scales which had been previously tested for correctness. The load was obtained by a water rheostat.

Two sets of indicator diagrams were taken, and the indicated horsepower was determined both by planimeter and by ordinate readings, and the planimeter readings being the smaller were accordingly selected by the purchasers' engineer. The indicator springs were removed by the purchasers' engineer immediately after the test and were calibrated by the indicator manufacturers, the Pratt Institute and the Stevens Institute of Technology, all calibrations agreeing.

After the tests the valves of both engines were tested for steam tightness by placing the valves on center, removing the indicator piping and opening the throttle to full boiler pressure. Neither engine showed any valve leakage.

As far as published records go, the results of these two tests establish a record for noncondensing steam engines of this type, operating under saturated steam conditions. The results are all the more noteworthy on account of the fact that the engines had been in operation for 14 months, without refitting of valves.

RESULTS OF TESTS

Date of trials	Oct. 6, 1912	
Type of engines	Tandem compound automatic noncondensing	
Class of engines	Direct connected to alternators	
Rated power, indicated horsepower	320	384–400
Type of valve	Skinner steam tight	
Dimensions	15½x25½x20	16½x28x20
Diameter of piston rods, in	2 15/16 & 3½	2 15/16 & 3½
Duration of tests, hr	4	3
Length of time engines were running at normal speed, hr.	6	5
Total water fed to boilers, lb	23,355	23,185
Total water fed per hour, lb	5,838.75	7,728.33
Loss of steam and water per hour, due to drips, lb	87.25	97.00
Loss of steam and water per hour, due to leakage, lb	659.00	659.00
Moisture in steam near throttle by throttling calorimeter, per cent	1.72	1.43
Net dry steam consumed per hour (equals water fed, less drips, leakage and moisture), lb	5,004.91	6,872.63
Steam at throttle, by gage, lb	132.56	131.23
Back pressure at mid-stroke above atmosphere, lb. per sq.in	1.00	0.95
Revolutions per minute	202	200
Average indicated horsepower:		
High-pressure cylinder	147.26	209.70
Low-pressure cylinder	130.30	178.28
Total	277.56	387.98
Approximate load	¾	Full
Water as fed per i.hp.-hr., lb	21.04	19.92
Net dry steam consumed per i.hp.-hr. (equals water as fed less drips, leakage and moisture, lb	18.13	17.81

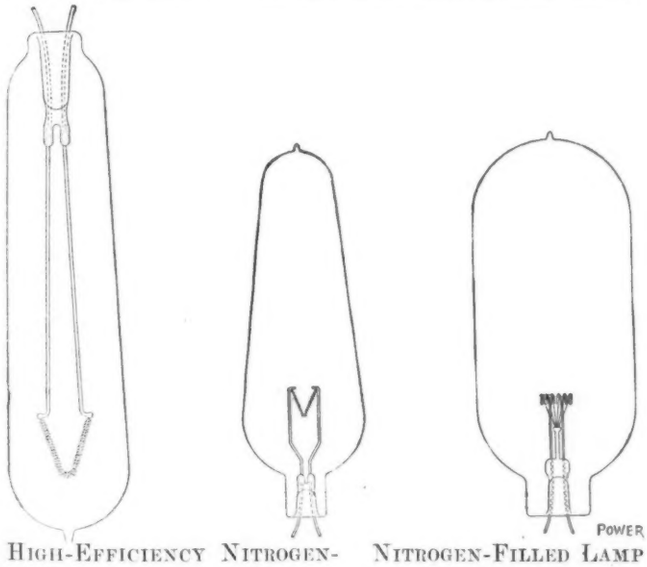
Peat Production Small—While the United States is the richest country in the world in the deposits of peat, little active work is done in mining or digging it. So far as is known very few of the peat-fuel plants established have gone beyond the experimental stage and many of them have never been equipped with essential machinery. Reports from all known peat-fuel plants in the United States, according to an advance chapter from "Mineral Resources, 1912," on the production of peat in 1912, by Charles A. Davis, show that with one exception they were idle during the summer of 1912. The output of peat fuel was reported as about 1300 tons, valued at $4550. All this peat was sold. A copy of the report on peat may be obtained free on application to the Director, U. S. Geological Survey, Washington, D. C.

ELECTRICAL DEPARTMENT

The Half-Watt Tungsten Lamp*

The first carbon-filament incandescent lamps consumed 5 to 6 watts per candlepower, but were gradually improved to about 3.1 watts. During the past few years this has been further decreased by the use of the metallized filament to 2.5 watts per candlepower. Moreover, since the introduction of the metallized-carbon filament progress with other types has been comparatively rapid and at the present time the most efficient incandescent lamp in commercial use is the tungsten, utilizing from 1 to 1¼ watts per candlepower in the ordinary sizes.

Notwithstanding this improvement the luminous efficiency of the ordinary tungsten lamp is not more than 6 to 10 per cent. If the maximum theoretical efficiency



HIGH-EFFICIENCY NITROGEN-FILLED LAMPS FOR LOW-VOLTAGE CIRCUITS

NITROGEN-FILLED LAMP FOR 110-VOLT CIRCUIT

were attained the consumption should not be more than 0.1 watt per candlepower.

It has long been known that ordinary tungsten lamps can be run at voltages much higher than rated and in this way extremely high efficiencies can be obtained, but the life of the lamps under these conditions is very short.

In ordinary practice the useful life of a lamp is considered to be the time which the lamp burns before its candlepower has fallen to 80 per cent. of its original value, or until the filament breaks, in case this occurs while the candlepower is still above 80 per cent.

The causes which made it necessary to operate tungsten lamps at such relatively low efficiencies were little understood at first and led to a series of exhaustive investigations at the laboratories of the General Electric Co.

The lamps were observed, ordinarily, to fail in one of two ways: either by breakage of the filament or by blackening of the bulb. The former difficulty was largely overcome by employing ductile tungsten and by improved methods of mounting the wire, but the blackening of the bulb continued to baffle the investigators.

At first this blackening was thought to be due to the presence of residual gases. These were determined, but experiments showed water vapor to be the only one which produces perceptible blackening of the bulb. In this case the process is cyclic; that is, the water vapor oxidizes and deposits on the bulb, where it is reduced by the free hydrogen, forming water vapor and leaving metallic tungsten.

Attempts to materially improve the life of the lamps by the more complete removal of water vapor resulted in failure, and it was concluded that, although water vapor is usually one of the principal causes of short life in poorly exhausted lamps, it is not the cause of blackening in well exhausted lamps. The real cause of blackening in well made lamps was finally proved to be due to evaporation of the filament.

It, therefore, follows that to improve the efficiency of tungsten lamps, either the rate of evaporation of the filament must be reduced or the evaporated tungsten must be prevented from blackening the bulb.

This result has been accomplished by the introduction of nitrogen into the bulb under atmospheric pressure and by changing the location of the deposit by means of convection currents so that the bulb opposite the filament does not darken. By making use of these principles the General Electric Co. has been able to construct practical tungsten lamps which have burned over 2000 hours at an average efficiency of less than 0.5 watt per candlepower. At the present stage of the development, however, it has been possible to attain these results only in large-sized lamps—over 1000 cp., as will be explained.

It was found that a much higher efficiency could be obtained when using large filaments than with those of small diameter, due to the relatively greater heat loss by convection from the small wires. Moreover, the life of the filament is determined largely by the loss of tungsten through evaporation and has been found to be dependent on the relative decrease in diameter caused by this evaporation.

If the rate of evaporation per unit area from large and small wires were the same, the lives of various filaments run at a given temperature would be approximately proportional to their diameters. However, as the evaporation of tungsten in nitrogen is largely a diffusion process, it probably obeys laws similar to those of conduction or convection of heat from a wire; that is, for wires of small diameter the actual amount of tungsten evaporated would be nearly independent of the size of the wire. The rate of evaporation per unit area would thus be approximately inversely proportional to the diameter. The relative lives of very small wires in nitrogen are therefore nearly proportional to the squares of their diameters.

*Abstracted from a paper by Irving Langmuir and J. A. Orange, read before the American Institute of Electrical Engineers, at New York, Oct. 10, 1913.

However, it is not desirable to use filaments of very large diameters if similar results can be obtained with smaller ones, as the current increases as the three-halves power of the diameter of the filament. Hence, unless very low voltages are used, the power consumed by the larger wires is so great that only very high candlepower lamps can be made. Therefore, it is of vital importance to increase the effective diameter of the filament without decreasing its resistance. The most satisfactory method of accomplishing this is to wind the filament into the form of a tightly-coiled helix of as large a diameter as practicable. It has been found that the use of a helically wound filament increases the life of the lamp many times beyond that which would be obtained with a straight filament running at the same efficiency. This is especially true of the smaller sizes of wires.

In ordinary lamps about 20 per cent. of the energy radiated from the filament is intercepted by the glass and causes heating of the bulb. In the nitrogen lamp, besides this radiated heat there is additional heat carried to the bulb by convection—an amount varying with the type of lamp and ranging from 6 to 40 per cent. of the total input. The convection currents carrying this relatively large amount of heat travel vertically upward from the filament and strike a small area of the bulb, which thus tends to become greatly overheated. Unless special precautions are taken, this overheating will cause the liberation of enough water vapor to attack the filament and blacken the bulb. It is therefore desirable, if small bulbs are to be used, that the filament be mounted in the lower part. By special designs of bulbs satisfactory lamps have been made in which, for the same volume, nitrogen lamps give from five to ten times the candlepower of evacuated lamps.

The principal limitation of the new type is that of current. There is no practical upper limit to the current, provided the voltage is not lowered to keep constant power consumption. With increasing current, larger and larger filaments are used and the efficiency that may be practically reached increases toward the limit of 0.2 watt per cp., which is fixed by the melting point of tungsten.

For the particular type of nitrogen-filled lamp which has at present been furthest developed, it may be said that a life of over 1500 hours is obtained at efficiencies better than 0.5 watt per candlepower only in large units taking over 10 amp. Lamps consuming 0.6 to 0.7 watt per candlepower have been made, taking at least 5 amp.

No serious difficulty has been met in making high-voltage lamps. In nitrogen at atmospheric pressure there is no tendency toward arcing, even at 250 volts. Many lamps taking 6 or 7 amp. at 110 volts have been made and run at 0.6 to 0.7 watt per candlepower with a life of 1000 hours.

Waterwheel Generators

Waterwheel generators are being built to conform with the rapid development of hydraulic power in various combinations of capacity and speed range. The following deals with the practice of one large company—the Westinghouse Electric & Manufacturing Co.—in this line.

Horizontal Type

The standard horizontal unit is of the two-bearing coupled-type construction; that is, the generator includes the shaft, two bearings, and a bedplate usually designed to allow for sliding the stator to one side in case ready access to either the stationary or rotating winding is desired; see Fig. 1.

The stationary frame is a rigid iron casting, into which soft steel laminations are dovetailed and securely fastened. Form-wound, interchangeable armature coils fit into parallel open slots punched in these laminations, and these coils are held firmly in place by fiber wedges. The coils are insulated and impregnated with fabrics and high-insulating compounds.

No single type of construction will meet the varied requirements in rotor design, therefore, several well tested methods are employed. When comparatively low peripheral speeds are encountered a cast-iron spider with bolted-on, or dovetailed poles, is usually employed. For higher speeds cast-steel or steel-plate construction may be used. In the case of very large relatively high-speed machines, the difficulty of securing perfect castings may lead to the well proved laminated rim structure, which is illustrated in Fig. 2.

All the field poles are made of thin steel laminations riveted together with overhanging pole tips provided to support the field windings.

The field coils are of heavy copper strap wound on edge and insulated in such a way that each individual turn is exposed to the ventilating air. The coil is fastened between the rotating spider and the tips of the field poles by heavy coil supports.

Vertical Type

Standard practice recommends that the generator be fitted with two guide bearings which are supported by brackets fastened to the stator frame, also, a bedplate or pad on which the stationary part rests.

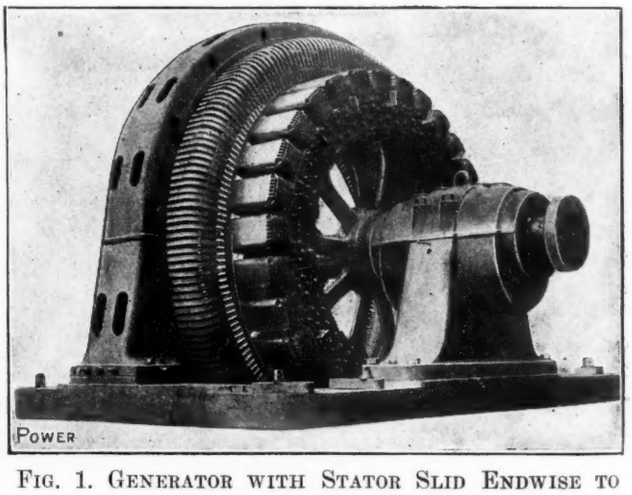


Fig. 1. Generator with Stator Slid Endwise to Permit Access to Rotor

The roller, or thrust bearing, which supports the weight of the revolving part may be mounted on top of the generator frame, between the generator and turbine, or underneath the turbine. In case it is mounted on top of the generator frame, this frame must be heavier and more expensive than where it has only to support the stator punchings, winding and guide bearings. Wherever placed, this bearing usually supports not only the rotor of the generator, but also the turbine runner, and in addition takes care of any unbalanced water thrust.

A rigid cast-iron frame into which soft steel laminations are securely dovetailed, forms the basis of the stator. Form-wound, interchangeable armature coils are held in open slots by means of fiber wedges. The coils are vacuum dried and impregnated before the outside insulation is applied. This outside insulation consists of wrappings of paper and mica on the straight parts of the coils which lie in the slots, and servings of treated cloth over

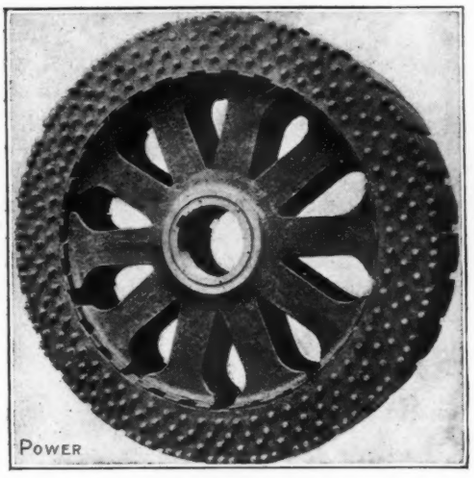


FIG. 2. LAMINATED-RIM ROTOR WITHOUT FIELD POLES

the V-shaped coil ends. After the outside insulation is applied the coils are treated with an insulating varnish which renders them moisture- and oil-proof. An insulating cell is provided in each armature slot to prevent abrasion of the coil and a fiber wedge holds the coils and cell firmly in position.

There are several designs of rotors, each especially adapted to the requirements for which it is used. Comparatively low peripheral speeds may permit the use of a cast-iron spider with either bolted-on or dovetailed poles. A higher speed generator may demand an entirely different construction. For such work cast-steel or rolled-steel plates are often employed. In case of very large machines, it may be difficult to obtain perfect castings, and here the well proved laminated-rim type of construction may be employed.

Field coils are ordinarily wound with heavy copper strap on edge and insulated between turns with asbestos. This construction is well adapted to give perfect radiating qualities and because of the heavy strap used is practically indestructible. The coils are securely fastened between the rotating spider and the projecting tips of the field poles by heavy coil supports.

Power-House Protection

The committee on power generation of the American Electric Railway Engineering Association recommends the following arrangements to protect power plants from shutdowns.

1. In all central stations, sufficient reactance should be provided in the generator circuit (either inherent in the generator or including external reactance) to limit the short-circuit current to a value which the apparatus to be protected can safely withstand.

2. In stations of large capacity or where excessive voltage disturbances at the busbars occur, reactances should be installed in the feeder circuits on the line side of the oil switches and in special cases between busbar sections.

3. In all outgoing feeder circuits, overload relays of suitable time characteristics should be installed.

(a) Instantaneous, on simple load distribution lines but normally used.

(b) Inverse time element, on overhead or underground transmission lines.

(c) Definite time element, in special cases on lines where conditions may demand the maintenance of power supply at all hazards.

(d) Reverse energy or current, on important tie lines and in switching or substations.

4. Install reverse energy or current relays on generator oil switches, or preferably on large generators use an adaptation of the Merts-Price system.

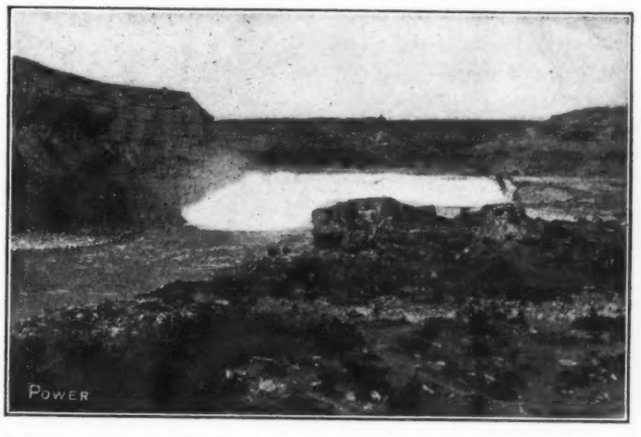
5. Use proper lightning-arrester equipment in all outgoing overhead feeders and in addition thereto, in special cases, directly on the bus.

6. Use mechanical or electrical interlocks to prevent improper switching.

7. Grounded neutral, preferably with resistance, may be employed to advantage, especially in connection with underground lines subject to frequent high-voltage surges.

Large Hydro-Electric Development in Montana

A large hydro-electric development is under way at the Great Falls of the Missouri, about 12 miles below the city



SITE OF GREAT FALLS DEVELOPMENT ON THE MISSOURI RIVER

of Great Falls, Mont. The power house when completed will contain six units, each of 15,000 hp., or a total of 90,000 hp. at a maximum head of 153 ft.

Generator for Use with Diesel Engines—Because of the nonuniform turning moment of an internal-combustion engine, necessitating a big flywheel effect, says "The Engineer," of London, the Oerlikon Co. has recently developed a new form of alternator for coupling to Diesel engines. It is built on the "outer pole" principle, that is, instead of the field magnets revolving inside the armature they revolve outside of it. Hence, for a given rim weight the flywheel effect is greater, in direct proportion to the squares of the diameters of the wheels, than that of the ordinary type of flywheel alternator.

HEATING AND VENTILATION

Sizing Pipe for Gravity Hot-Water Heating

The accompanying chart has been used with success by M. S. Cooley in determining the size of pipe for gravity hot-water heating systems. All of the variables appear in the chart, and the result, that is, the size of pipe, may be read directly. No computations are necessary. The derivation of this chart, which is plotted on logarithmic paper, and the method of using it, was made the subject of a paper read before the American Society of Heating and Ventilating Engineers at Buffalo. Passing over the derivation, the instructions for the use of the chart, as given by the author, follow:

One-Pipe System—Main in Basement

Radiator tappings, branches and risers: First ascertain the distance from the bottom of the flow main to the top of the radiator. Find this number at the base of the table and follow vertically to the intersection of the line inclined toward the right near the top of the table corresponding to the difference of temperature desired between flow and return connections to the radiator. Now follow the horizontal line passing nearest to this intersection toward the left until it intersects the dotted line inclined toward the right, and corresponding to the length of connections from the main to the radiator and back plus:

For each long-turn elbow or gate-valve, 5 ft.

For each short-turn elbow or angle-valve, 10 ft.

For each globe valve, 20 ft.

Now follow the vertical line, passing nearest to this intersection to its intersection with the horizontal line opposite the figure in the left-hand margin corresponding to the amount of radiation to be supplied, and the solid diagonal line inclined toward the right that passes above this intersection is the size of pipe required.

Example: Elevation, 6 ft.; temperature difference, 15 deg.; equivalent length, 50 ft.; radiation, 100 sq.ft. What size of pipe is required?

Follow the line from 6 at the base of the table to the intersection with the diagonal 15 deg. They intersect on horizontal line 2800; then follow line 2800 to intersection with dotted diagonal 50. From this intersection drop down to the horizontal line 100. The solid diagonal inclined toward the right above this intersection is 2 in.; therefore a 2-in. pipe will be required.

There is still to determine the head necessary to produce velocity. To obtain this find the diagonal line inclined toward the left passing nearest to the intersection of diagonal 2 and horizontal 100. This is 10, the constant for velocity head. Follow horizontally from the figure in the right margin near the bottom corresponding to this constant to its intersection with the lower diagonal 15 deg., and the head to produce this velocity is found in the lower margin. In this case it is 0.14 ft. This must be added to the friction head. In nearly all gravity work this velocity head is so small it may be neglected.

If it is desired to know the pressure in ounces per square inch equivalent to this head and temperature difference, follow the vertical 6 at the bottom of the chart to its intersection with the broken diagonal 15 deg., near the center of the table. Then follow the horizontal line to the right margin, where the pressure in ounces per square inch is found to be 0.2.

To ascertain the size of main, use the distance of the flow main at its lowest point to the bottom of the boiler as elevation, and the length of the main from the boiler back to same plus allowance for elbows, valves, etc., as equivalent length. Use a drop greater than that assumed through the radiator, and proceed as explained for the radiator.

Two-Pipe Reversed Circulation System

With the flow main in the basement, measure the total water travel from the boiler to the first-story radiator and back to the boiler, plus allowance for fittings as equivalent length. Use the distance from the bottom of the boiler to the top of the first-floor radiator as elevation. Ascertain sizes for the first floor. In a like manner ascertain sizes for the second floor, third floor, etc. Now combine these sizes into a single pipe having equal carrying capacity in the following manner:

Note the figure on the left-hand margin, corresponding with the intersection of the diagonal for each pipe size. Take the sum and the pipe diagonal intersecting the margin at this sum is the size desired.

Example: Take two 1-in., three 1¼ in., and one 1½-in. pipes and find a pipe of equivalent carrying capacity.

Pipe, in.	Intersection		Number		
1	10	×	2		= 20
1¼	18	×	3		= 54
1½	29	×	1		= 29
					103
2½	110	×	1	=	size required

This neglects velocity head and is permissible for gravity work only. If the system is not laid out to give equal water travel to each radiator then ascertain the pipe size for each equivalent length and find the pipe of equivalent carrying capacity to the sum of pipes it serves.

Often there are two pipes to equalize, neither of which is fully loaded, and if they are equalized as in the foregoing too large a pipe will be obtained. In such cases, and it is better to in all cases, run imaginary lines from the intersection by which the pipe size was determined, parallel to the pipe-size diagonals to the margin and add the quantities so found to determine the equivalent pipe size.

Example: Elevation, 6 ft.; temperature difference, 15 deg.; length, 50 ft.; radiation, 100 sq. ft.; 2-in. pipe required. Elevation, 20 ft.; temperature difference, 15 deg.; length, 75 ft.; radiation, 100 sq. ft.; 1½-in. pipe required.

To combine a 1½-in. and a 2-in. pipe will require 29 + 62 = 91 = 2½-in. pipe.

Projecting the imaginary diagonals gives 23 + 39 = 62, so that a 2-in. pipe is sufficient.

By noting the intersection of the imaginary diagonal with the margin at each determination, as well as the pipe size, the combining can be quickly and correctly accomplished by addition of these notations.

Overhead System—Single-Pipe Drops

Use one-half the vertical distance from the flow main to the bottom of the boiler as the head. Make the drops the same size for the entire length and large enough to supply the total radiation on such drop. Use the temperature difference for the system divided by the number of stories heated as the temperature difference for each radiator in determining the size of radiator connections. Use the total water travel from the boiler back to same plus allowance for elbows, valves, etc., as equivalent length. If all drops do not have the same water travel determine the size of the main to supply each drop

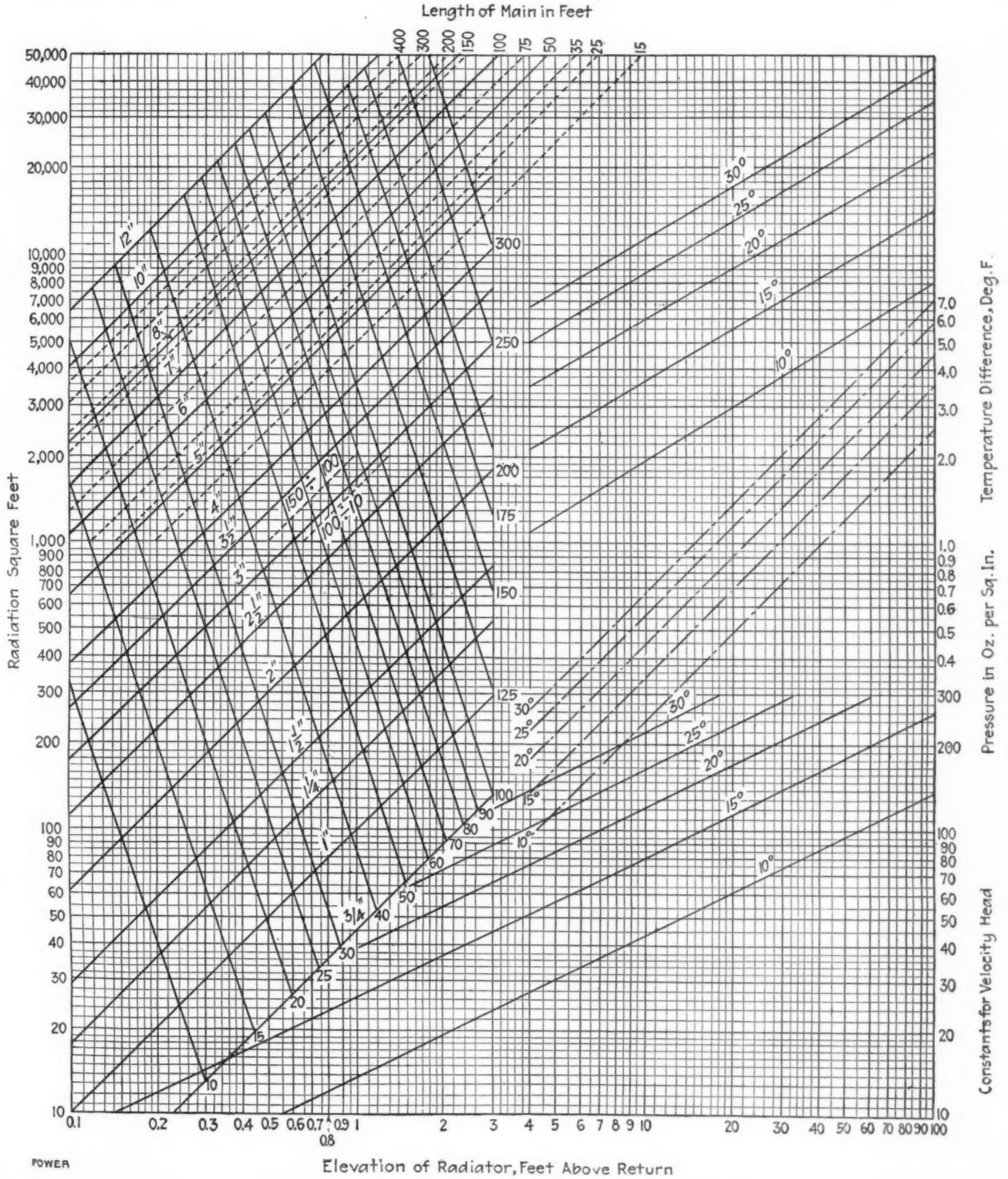

Length of Main in Feet
Radiation Square Feet
Temperature Difference, Deg. F.
Pressure in Oz. per Sq. In.
Constants for Velocity Head
Elevation of Radiator, Feet Above Return
POWER

Chart for Sizing Gravity Hot-Water Heating Pipes

separately and combine, as herein directed, to determine the size of the main.

OVERHEAD SYSTEM—DOUBLE-PIPE DROPS AND DROP INSULATED

Use the distance from the top of the radiator to the bottom of the boiler as the elevation for that radiator, and the total distance from the boiler to the radiator back to the boiler, plus allowance for elbows, etc., as the equivalent length. Ascertain the size of pipe for each story separately and combine into pipe of equivalent capacity. If drops do not have the same water travel determine the size of the main to supply each drop separately and combine to determine the size of the main.

In event the drops or risers in any system are exposed in the rooms there will be a certain amount of cooling in the risers, which is hard to determine. This will tend to aid circulation in an overhead system and retard circulation in a system with flow mains in the basement.

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Air Washer vs. Centrifugal Collector on Dust-Collecting Systems

BY JAMES D. WHITE

In the ordinary dust-collecting system a large amount of warm air is removed from the room containing the machines. The removal of this air is necessary, since for a material of given weight and character a definite number of cubic feet of air is required. During the months of the year when heat is not required the dust-removing system performs useful functions in addition to removing the dust by providing ventilation for the room. In the cold weather, however, this ventilation is provided at the expense of the heat required to raise the temperature of the air leaking into the room to the normal temperature maintained in the room. In certain cases buildings have a surplus amount of heat, due to manufacturing processes, in which case no additional expense would be incurred by the removal of the warm air from the building. As a usual thing this extra heat has to be provided at the expense of furnishing additional radiation in the building.

To form an opinion of the relative merits of the two systems, viz., air washer and centrifugal collector, the following calculations were made for a typical exhaust system from roll machines in a rubber factory.

As a basis of calculation it was assumed that the cost of the fan, piping, erection and freight would be the same for either system, also that the friction through the air washer would place the same resistance on the fan as the friction in the dust collector.

The apparatus was designed to remove the dust from 18 machines, each provided with a 7-in. connection. Assuming a suction of 2 in. of water at the hood and a coefficient of influx of 0.70, a velocity of 4000 ft. per min. would be required in the 7-in. connections.

The area of a 7-in. pipe is 38.5 sq.in., or 0.267 sq.ft., and

$$0.267 \times 4000 = 1068 \textit{ cu.ft.}$$

of air per min. per connection. Then

$$1068 \times 18 = 19{,}224 \textit{ cu.ft. per min.}$$

or 1,153,440 cu.ft. per hr. The heat required to raise 1,153,440 cu.ft. of air per hour from zero to 65 deg. would be

$$\frac{1{,}153{,}440 \times 65}{55} = 1{,}363{,}156 \textit{ B.t.u. per hr.}$$

With an air washer in use this air could be recirculated at nearly a constant temperature. If a dust collector were used the air and heat would be thrown away.

With steam at 5 lb. gage pressure it would require to supply the above loss in heat

$$\frac{1{,}363{,}156}{960} = 1420 \textit{ lb.}$$

of steam per hour. The transmission from pipe coils is about 300 B.t.u. per sq.ft. of surface per hour. Then

$$\frac{1{,}363{,}156}{300} = 4544 \textit{ sq.ft.}$$

of pipe coil would be necessary to supply the heat waste under maximum conditions.

Dividing the pounds of steam required per hour by 34.5 gives 41 hp. in boiler capacity necessary to supply steam to the coils. At $12 per horsepower installed the boilers would cost $492. A conservative price for pipe coils is 25c. per sq.ft., which would amount to $1136 for the total amount of extra radiation.

The cost of a dust collector for the above work is $300. The cost of a suitable air washer is $875. The air washer would be driven by a 3-hp. motor and assuming an efficiency of 80 per cent. for the motor, an input of 3.75 hp. or 2.8 kw. would be required. If the plant were operated 10 hr. per day for 300 days per year, the cost of electricity for running the air-washer pump with current at 3c. per kw.-hr. would be

$$300 \times 10 \times 0.03 \times 2.8 = \$252$$

A conservative figure for coal consumption is 65 lb. of coal per year per square foot of direct radiation. The fuel consumption would, therefore, be:

$$\frac{4544 \times 65}{2000} = 147.6 \textit{ tons per year}$$

At $3 per ton the cost of extra fuel would be $443. The cost of using a collector, exclusive of the parts common to both, would be

Dust collector	$300
Boiler	492
Coils	1136
Total	$1928

Deducting the cost of the air washer, which is $875, leaves $1053, which is the balance in favor of an air washer. Interest, repairs and depreciation at 15 per cent. would amount to $158.

The excess cost per year of the system using a collector would be:

Interest and depreciation	$158
Fuel	443
Total	$601
Deduction for running pump	252
Balance	$349

This is the net saving per year in favor of the system using an air washer.

With a suitable screen for straining the water recirculation can be employed, involving a small outlay for water. Slightly greater expense for attendance may be necessary with a system using an air washer over a system using a collector. This, however, would be a small item. It would appear that a substantial profit can be made by using the air washer.

EDITORIALS

Application of the Nitrogen-Filled Lamp

With the announcement of another important development in the field of electric lighting, namely, the half-watt tungsten lamp, the question arises as to what extent it will displace the less efficient types now in use.

At present there seems little likelihood that it will be applied to the smaller sizes, that is, forty watts and under, which constitute about seventy-five per cent. of the tungsten lamps now in use. In these sizes the life of the lamp is determined more often by breakage of the filament than by evaporation of the tungsten and consequent blackening of the bulb. Moreover, laboratory experiments indicate that with the smaller nitrogen-filled lamps, the additional heat losses due to conduction and convection more than offset the saving due to decreased evaporation of the filament. It is only where filaments of greater diameter are used that the reverse is true.

Being confined, then, for the present at least, to the large sizes, the field for the new lamp will probably be in street lighting, hall lighting, and, in fact, wherever units of high candlepower are required. Already a lamp with a specially wound filament of high light concentration has been devised for lantern use. Owing to the steadiness of the light it appears better adapted for this service than the arc and leaves the operator free to give his entire attention to the slides or film.

To what extent the new lamp will displace the arc lamp for street lighting would be difficult to predict. Being a close competitor it will undoubtedly put the arc-lamp manufacturers on their mettle and we may, therefore, expect further improvements in this type.

We understand that the General Electric Co. has found the argon-filled lamp even more efficient than the nitrogen-filled, and as soon as a comparatively inexpensive means of producing this element in large quantities is devised it contemplates putting these lamps on the market.

Boiler Explosions

Boiler explosions may not be more common than heretofore, but they are certainly more numerous than they need be. Many users of steam boilers do not know what an immense amount of energy is contained in even a small boiler and they therefore take risks and compel others to take risks that are frequently entirely needless. Further, the men who pay the bills are not usually around the boiler very much and the danger is even less real to them than it would be if they were where they could hear escaping steam and see the hot fire under the boiler. They, therefore, compel the man whose bread and butter depends on his ability to hold his job, to take the risk. Frequently he does not dare say very much because he would be likely to lose his position if he did.

There seems to be no single remedy that will eliminate this danger as completely as it can be eliminated. If all possible remedies could be coördinated, the best results would be obtained and the number of boiler accidents would be reduced.

Two instances may be related, one in which the boiler exploded and the other in which it did not explode though it certainly had more than ample provocation, which illustrate two more sides to the danger of boiler explosions.

A short time ago POWER told of a boiler explosion that was certainly preventable and of which the owner had ample warning. It was a portable boiler having an internal-flue furnace. The furnace had bagged and the boiler was taken to a shop for repairs, but the repairman refused to make them on account of the dangerous condition of the boiler. The owner, therefore, pushed the bagged sheet back into place while the metal was cold, after which the engineer became so convinced that the boiler was unsafe that he gave up his job. Some time afterward the boiler exploded.

On another page is related an experience quite the reverse where the owner took the boiler out of commission when warned of its dangerous condition and no explosion resulted. The remarkable feature is that the boiler—a very old one and badly abused—had not exploded long before the repairman was called in.

Both of these instances prove the need of laws compelling the inspection of steam boilers and the employment of competent licensed men to operate them.

Interest in Educational Work

Criticism of the report of the Educational Committee of the National Association of Stationary Engineers was invited in an editorial in the October number of the *National Engineer*. We take this occasion not to criticize but to offer friendly and well intentioned comment on the report.

The National Association of Stationary Engineers surpasses all others composed of operating power-plant engineers. The membership totals more than twenty-one thousand, and its chief aim, as stated in its preamble, is to give preference at all times to the education of engineers.

The Educational Committee and its Advisory Board planned and put forth some excellent educational schemes last year. The sets of prize questions, including two advanced and two elementary sets for which a total of five hundred and ten dollars was offered for the best twelve sets of answers, three of the prizes being offered for each set, were very good. The prizes, too, were substantial, ranging from twenty dollars for the lowest to seventy-five for the highest prize. But the committee reports that only a total of fifty-one members entered the contests. Out of over twenty-one thousand engineers, all of whom would be benefited by competing in such work, only fifty-one responded—twenty-four one-hundredths of one per cent. of the membership!

The committee also reported that of the three hundred and forty or more associations, only three entered the contest for the four prizes offered for meritorious educational work, although the contest was advertised twice. There is no excuse for this wholesale indifference to the opportunities for power-plant education offered by the committee.

Surely there never was a time when power-plant engineers needed to devote themselves more closely to engineering education than the present. This is not solely because of the activities of the central stations, but because modern methods are forcing the engineer to realize that the dollar has the same value in the power end of the establishment that it has elsewhere. These conditions demand that engineers shall be better men technically than their fellows of yesterday. This knowledge must be acquired by most men through home study. Why, then, do so many members of engineering organizations remain indifferent to the advantages offered by the educational committees?

If it is because the men do not realize that conditions affecting them and their work are changing, then let efforts be directed toward making them realize that they are. If it is because those that show indifference show it willfully and refuse to be stimulated to action by proper educational methods, then it would seem that money appropriated for educational purposes is practically thrown away.

Membership in engineering educational bodies should denote progressiveness on the part of the members. Let each man manifest more of this spirit during the coming season than was shown during the season just passed.

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Tied to the Plant

In a letter published on another page, the writer says: "I have known chief engineers who have not taken a vacation in from ten to fifteeen years. In one instance the chief engineer had not been twelve blocks from his power house in six years." He wants to know the reason why.

If we were to hazard a guess it would be that the engineer believes he is the only man capable of running the plant, or else he has not surrounded himself with men who can work out of commonplace difficulties, which in nine cases out of ten is his own fault.

When an engineer has grown up with a steam plant and has seen all of the apparatus installed to the smallest pipe line, it is natural that he should feel he knows the layout better than any other man. He cannot bring himself to admit that an experienced engineer, in a few months, can so familiarize himself with the operating conditions that the chief's presence is not necessary to keep things moving.

When a chief engineer reaches the stage where he feels the plant cannot run without him he is not only deluding himself, but is not giving his assistants credit for much intelligence. It is easy to get into this way of thinking, but it is seldom justifiable. Every man has his own way of doing a thing. Because it is not the way the chief would do it does not necessarily mean that it is not an economical or workmanlike way. Every chief should give his men the right to think for themselves and do their work in their own way, so long as the desired results are obtained.

One chief engineer of a large central station stated that he lived too near the plant for his own good or that of his men. Whenever anything went wrong, someone would rush to his house, regardless of the time of night, and get him down to the plant to help or advise them, when, had he lived at a distance, the men would have got out of their trouble alone. A chief engineer should train his men to act for themselves and so long as they are doing the right thing, let them alone.

If a child were always carried it would never learn to walk. Just so with the engineer. Give him a free hand and there will be no reason why the chief cannot take a vacation or go any number of blocks from his plant.

Another reason for keeping close to the plant, perhaps more weighty with some chiefs, is the fear that their assistants will get their jobs. A man who knows his business need have no such fear; if he does not know his business, a change will eventually occur anyway. Further, a chief who labors under such misgivings cannot do justice to either himself or to his men. Suspicion will be directed to every movement, which will be detected by the men and unfriendly feelings will develop.

Every steam plant requires a chief engineer. His position is to direct, not act as emergency repair man. If his assistants are given to understand they are to get out of their own troubles, it will not be long before they will stop calling the chief every time a water glass breaks. Confidence in themselves will make them better engineers and capable of running the plant under ordinary conditions. The chief can then take his vacation and go as far as he likes.

❋

Among many engineers there arises discussion as to the incidents surrounding the origination of the term horsepower as applied to the steam engine. The following quotation from "Farey on the Steam Engine," published in 1827, will be welcomed by many. Mr. Farey was a personal friend of Mr. Watt and lived during the time that the steam engine was being developed from a machine utilizing the pressure of the atmosphere on the piston to an engine using steam above atmospheric pressure and expansively in one or more cylinders.

> The machinery in the great breweries and distilleries in London was then moved by the strength of horses, and the proprietors of those establishments, who were first to require Mr. Watt's engines, always inquired what number of horses an intended engine would be equal to.
>
> In consequence, Mr. Watt made some experiments on the strong horses employed by the brewers in London, and found that a horse of that kind, walking at the rate of 2½ miles per hour, could draw 150 lb. avoirdupois by means of a rope passing over a pulley, so as to raise up that weight, with a vertical motion, at the rate of 220 ft. per minute. This exertion of mechanical power is equal to 33,000 lb. (or 528 cu.ft.) of water raised vertically through a space of 1 ft. per minute, and he denominated it a horsepower, to serve for a measure of the power exerted by his steam engines.

This estimate is much beyond the capacity of the average strong horse. Smeaton and other early engineers estimated that 22,000 lb. per min. was more accurate.

❋

The fireman who said, "Boss, what CO_2 percentage do you want today?" may have known his business, but the one who blew water to the sewer through the water-column drain because he was receiving a bonus based on capacity as indicated by the feed-water meter was not particularly dense.

READERS WITH SOMETHING TO SAY

Engineers' Wages

Referring to the question of engineers' wages, probably everyone concerned knows that the average operating engineer is paid less than an ordinary pipe fitter with the disadvantage that his time is hardly ever his own.

He never knows whether he will be able to get away on his day off or not. He is subject to call any hour of the night, if an oil cup stops up.

I have known chief engineers who have not taken a vacation in from 10 to 15 years. In one instance the chief engineer had not been twelve blocks from his power house in six years.

What makes a man do this? Not his salary, surely. It must be that he likes his profession, or is mentally deficient.

I am with a company which makes nearly all kinds of large power machinery. I visit a number of medium-sized and small plants each year. From what I see, it is a wonder that the central stations have not closed down more small plants than they have. A large percentage of them certainly have no right to exist under their present system of operation.

Take the case of the gas engine. The success or failure of a gas-engine installation depends 90 per cent. upon the operating crew. They should be on the job every minute, anticipating trouble, meeting it half way. A steam engine will run with the valve setting out, without oil for hours at a time, without serious immediate trouble. The gas engines demands constant attention, it either runs with economy or not at all. This is especially so in some cases of producer-gas engines.

Power machinery is usually sold under a year's guarantee. This has spoiled a lot of engineers. It is safe to say that gas-engine builders have more trouble about that one year's operation than the builders of steam prime movers. The operating engineer gets into the habit of putting his troubles up to the builder; he does not worry much about them. One chief engineer saw his plant only once a week for the year during which time the builders operated it. When the year expired, his company had to double the number of gas engines to get continuous service.

Repeatedly the builders' engineers travel hundreds of miles to make some slight adjustment which the operating man could do equally well if he were "on the job."

A company in the South bought three 300-kw. gas engines. The engines ran beautifully while the builder's engineers were in the plant, but a year later, after a series of troubles nearly all of which could be traced to lack of prompt attention, the company bought steam turbines of the same company who built the gas engines and shut the gas plant down.

The operating engineers must take a large share of the responsibility for the slow introduction of the gas engine to general use in this country. The gas engine is suitable for the medium-sized plant and engineers running them need not fear the central station. Their raise in wages will come out of the coal now thrown away.

J. R. BELKNAP.

New York City.

The Polar Planimeter on Circular Charts

Julian C. Smallwood, in the Aug. 19 issue of POWER, states that "the ordinary polar planimeter may be used to obtain approximately the average value of the quantity shown by a circular chart from a recording instrument," and proceeds to demonstrate this hypothesis by employing a pressure-recording chart on which has been

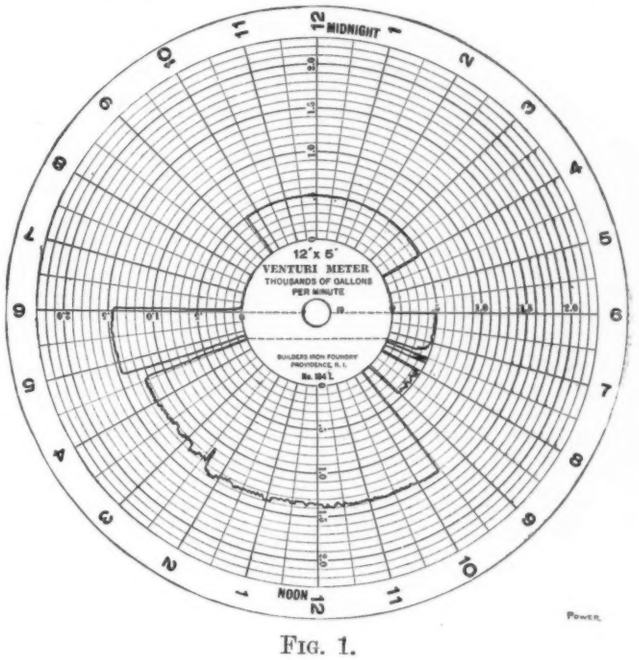


FIG. 1.

traced a continuous line showing an average variation in pressure of perhaps 20 lb. for a six-hour period. From the familiar formula,

$$Area = 3.14\ R^2$$

he obtains a value of 2.06 in. for the radius R which, when laid off on the chart, gives an average pressure of 97 lb. This checks, he states, with the value obtained by using a theoretically correct averaging instrument.

In order for the hypothesis to be of practical value we should know what the author means by the word "approximately." The meaning is apparently made clear in the closing sentence of the article which affirms that the error in the result with a polar planimeter on a circular chart, "except in extreme cases," is not greater than 2 per cent.

The writer does not agree in this conclusion with Mr. Smallwood. Generally speaking, the method used would be accurate enough for charts from pressure recorders

when the pressure is kept very uniform during the 24 hr. Should, however, a high steam pressure be maintained during the day and a low pressure during the night, as is often the case, the method in question would show an error much greater than 2 per cent., even though the pressure did not vary during each period.

There are now in use a great variety of recording instruments in engineering work where the rate or amount recorded often fluctuates widely from hour to hour. Without referring further to such charts, which might perhaps be called "extreme cases," let us consider an average record.

Fig. 1 is an exact reproduction of a circular chart from a 12-in. venturi meter in service at the pumping station of the East Providence Water Co., East Providence, R. I. The meter is on the discharge line of a centrifugal pump which is running for only a portion of the 24 hr. and is operated at different speeds as necessity requires.

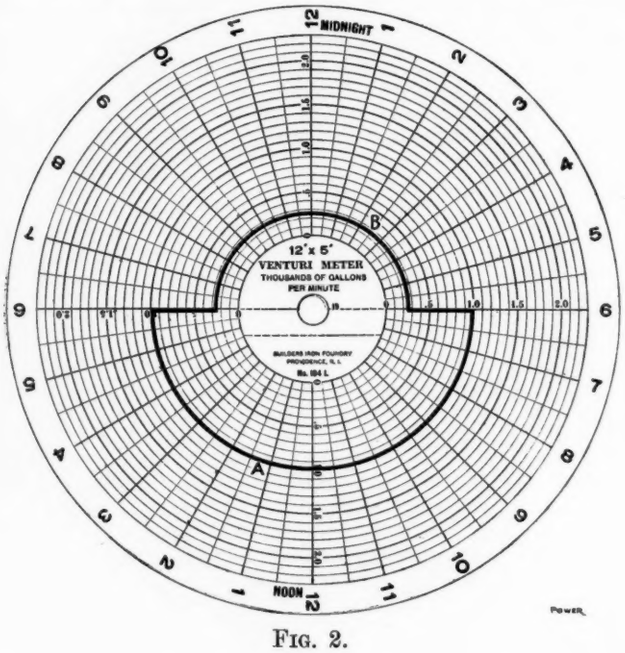


FIG. 2.

For instance, the chart discloses that at 9:30 p.m. the pump was started and discharged at a rate of 500 gal. per min. until 4 a.m., when it was shut down again. It is a simple matter to obtain the average rate during each 12-hr. period by totaling the half-hour rates and dividing by 24. This gives the following results: 6 a.m. to 6 p.m. average rate is 1000 gal. per min.; 6 p.m. to 6 a.m. average rate is 270 gal. per min.

In other words, the total pumpage obtained would be exactly the same had the pump discharged steadily at these average rates for the two 12-hr. periods named. A polar planimeter, if made to trace the shaded line, would show a total area equal to the area of the semicircle *A* plus the area of the semicircle *B*. On the actual chart this area equals 19.39 sq.in. Therefore, the average radius *R* equals

$$\sqrt{\frac{19.39}{3.14}} = 2.48 \text{ in.}$$

corresponding to an average rate, when laid off from the center of the chart, of 680 gal. per min. But the average rate by the first method is

$$\frac{1000 + 270}{2} = 635 \text{ gal. per min.}$$

and

$$\frac{680}{635} = 1.07$$

which shows that the polar planimeter is in error to the extent of 7 per cent. too great.

If the actual rate of discharge had been zero for the first 12 hr. and 2000 gal. per min. for the remaining 12 hr., the error by the polar planimeter method would have been 26 per cent. too great.

It seems evident, therefore, that the polar planimeter should be used with great caution on circular charts and that it is only of sufficient accuracy, even for practical purposes, when all of the autographic line lies in one narrowly confined portion of the chart. The safest method is to average by taking a large number of readings, depending upon the character of the record, or best of all to employ one of the new planimeters which have been devised especially for this purpose.

CHARLES G. RICHARDSON.

Providence, R. I.

Preventing Freezing of Air-Driven Pumps

Several years ago I visited a small stone quarry in which the largest engine was of about 150 hp. and operated by compressed air part of the time. The air supply came from the plant of a large company which used air for drills and other machinery, and had two 1200-hp. compressors. The two companies were about a mile apart. There was an 8-in. line from the compressor plant to the mill engine, hoisting engines, drills, etc., at the quarry. The pressure at the end of the line was about 120 lb. To prevent the air from freezing in the exhaust pipe of the engine, it was heated in a separately fired heater built like a separate-fired steam superheater. A large drip pocket was placed in the main on the cold-air side of the heater to drain out any entrained moisture that had separated from the air. The air was then passed through the heater where its temperature was raised to about 180 deg. F. The line to the mill engine was covered, but the line to the hoisting engines and drills was left bare. This gave practically no trouble from freezing in the exhaust ports. The heater was fired with coal, and did not require a great deal of it to keep the temperature up.

On what basis the small company purchased the air I do not know, but as the feed water at that plant was the worst I ever saw for forming scale, although it was as clear as glass, they found it cheaper or at least more desirable, to buy compressed air than to run the machinery by steam as the boilers were old, and not large enough to carry the full load. At times the 150-hp. mill engine was operated days by steam, and nights by air. In changing over from air to steam or *vice versa*, the engine was not shut down but the air and steam pipes were connected just above the throttle, and one was slowly opened and the other slowly closed. In changing from air to steam the cylinder cocks had to be left open for a few minutes until the cylinder became warm, as there was much condensation. This extreme change of

temperature must also have been very severe on the cylinder, but it was done for several years. The same grade of cylinder oil was used for air as for steam.

J. C. HAWKINS.

Hyattsville, Md.

In a coal mine close to the plant where I am employed, compressed air is used to operate the water pumps in the pit, which is situated some 3000 ft. from the compressor.

At the end of the air line is a small receiver and the pumps in turn are connected to the receiver. By frequently blowing the water out of the receiver or by leaving the bleeder valve slightly open they get comparatively dry air and are not troubled with the pumps or the drilling machines freezing up.

The letter from E. R. Pearce, of Rochdale, Eng., caused me to look back over the June 17 issue in regard to the water disappearance in T. G. Thurston's sight-feed oil glass, and I do not think that Mr. Pearce has made the right diagnosis of the trouble.

While glycerin will keep oil from sticking to the glass while working, I do not think that it would help this trouble as it would very likely disappear as the water did.

From the statement of Mr. Thurston's letter the explanation to me seems to be this: He stated that the two oilers that were giving him the trouble were connected to the steam chest and subjected to a 25-in. vacuum after the steam was cut off, which very likely draws the water out of the sight-feed glass into the steam chest. He states that when he closes the valve between the engine and the sight-feed glass the trouble does not appear. This evidently shows that the engine is drawing the water out of the glass.

If he will connect the feed above the throttle valve he will get better lubrication and his trouble will disappear.

D. E. ADEN.

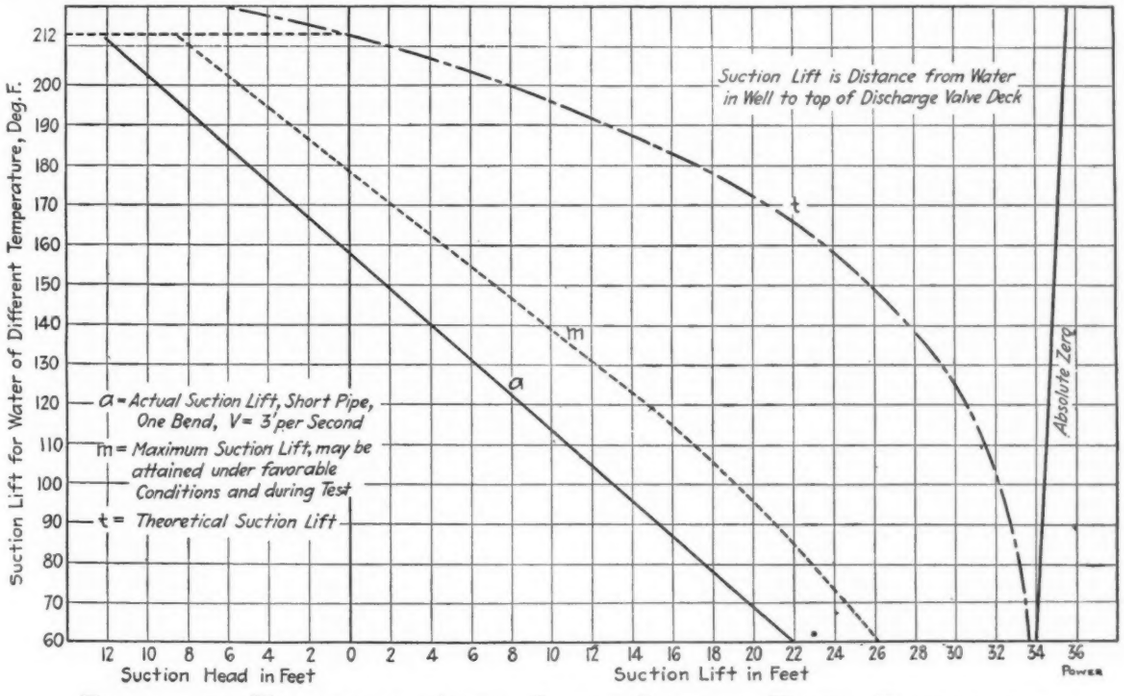
Wilburton, Okla.

Lifting Hot Water

The reply to F. D. S., in the Sept. 16 issue, was rather of a negative character and did not give him the desired information. He wanted to know the highest temperature at which water can be lifted by the suction of a feed pump to a height of 5 ft. and the reply gave him the theoretical temperature of 204.1 deg. F. and it was said that water at this temperature cannot be lifted 5 ft., stating the correct reasons why it could not.

The same condition prevails at any other temperature. Thus for a temperature of 60 deg. F. the theoretical suction lift is nearly 34 ft., yet we cannot safely lift water over 22 ft. This brings up the question: What limits the suction lift and why cannot this theoretical suction lift be approached more closely?

The reasons are manifold: Velocity head, entrance head, friction in pipe, losses in bends, losses through suction valves, inertia of water column, vapors from the water and air.



THEORETICAL, MAXIMUM AND ACTUAL SUCTION LIFTS FOR VARIOUS TEMPERATURES

At the low velocities usually encountered in the suction pipe, the first few items can be shown to be insignificant. The velocity should not exceed 180 ft. per min., or 3 ft. per sec. For this we have:

Velocity head

$$hv = \frac{v^2}{2g} = 0.14 \text{ ft.}$$

Entrance head

$$he = \frac{hv}{2} = 0.07 \text{ ft.}$$

The friction in the pipe will also be small for the same reason and for a short pipe, usually:

$$f = hv = 0.14 \text{ ft.}$$

Losses in bends

$$\textit{Each bend } b = \frac{hv}{2} = 0.07 \text{ ft.}$$

and for, say, three bends, 0.02 ft.

Losses through suction valves consist of friction which is insignificant on account of the low velocity and the shortness of the path, and the spring pressure which is usually

$$\frac{1}{4} \textit{ lb. per sq.in.} = 0.6 \textit{ ft. water column}$$

These five items added together give a total of 1.15 ft., which does not account for the loss of 12 ft.

The inertia or momentum of the water column is blamed by many for this condition and they proceed to calculate it for a single-acting pump without vacuum chamber, a type which does not exist. A duplex pump produces a very steady flow of water in the suction pipe and this is made still more uniform if a vacuum chamber is used at the pump and the same effect is attained by a large vacuum chamber on a single double-acting pump. The effect of the inertia need not, therefore, be taken into account.

The inertia of the water column is of great importance when hot water is being handled but does not explain the shortcoming on cold water.

Air remains as the only item to which we must look as the principal reason. Water under atmospheric conditions contains about 5 per cent. of air in solution. This air expands in the suction pipe and enters the water cylinder in this expanded condition, cuts down the capacity and causes shocks limiting the speed at which the pump can be operated safely.

Suppose we were to lift water 26 ft., which would give an absolute head of

$$34 - 26 = 8 \textit{ ft.}$$

The air would then expand

$$\frac{34}{8} = 4.25 \textit{ times}$$

and would fill

$$4.25 \times 5 = 21.25 \textit{ per cent.}$$

of the pump barrel. Fortunately, it is not so bad because the water passes through the suction pipe so quickly that all of the air has not time to liberate; otherwise we would not be able to lift water any height. This also shows why long suction pipes, where a greater chance is given to the air to separate from the water, are such a detriment to satisfactory pumping.

In the diagram the line marked absolute zero gives the height of a water column required to balance the atmospheric pressure. This is measured from the zero line marked *O*. This height increases with rising temperature. From this line the absolute pressure corresponding to the temperature is deducted and thus the line *t*, the line of theoretical suction lifts, is obtained. The line *a* is the actual lift attainable under ordinary conditions and is the maximum lift that might be attained during a test when everything is in perfect order.

It will be noted that the line *a* approaches the theoretical line at both ends and this is as it should be. At low temperatures the effect of the air is not so marked, because the air is not liberated so easily as at high temperatures, and if the water comes in under a head the effect of the air disappears likewise because it does not expand in the suction pipe but remains in a compressed state.

This curve answers F. D. S.'s question. At 5 ft. suction lift we find a point 135 deg. F. at line *a* and nearly 160 deg. F. at line *M*.

F. F. Nickel.

East Orange, N. J.

Leaky Piston

The diagrams herewith were taken from the cylinders of a compound marine engine 12 and 24⅛ by 15-in. stroke and are of interest in showing the kind of diagrams which were obtained from an engine in which the leakage past the high-pressure piston was so bad that at times it was difficult to start the engine on account of being steam-bound.

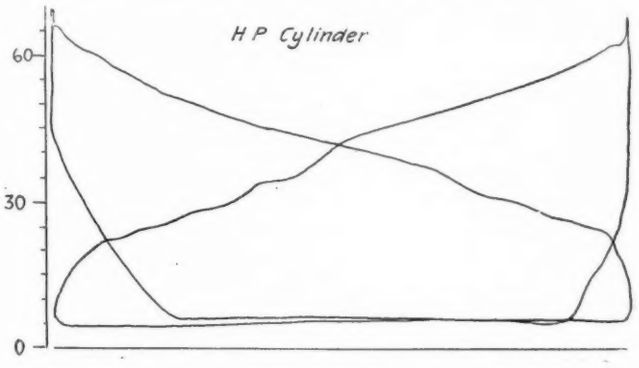


Fig. 1. Diagrams from 12x15 High-Pressure Cylinder with Leaky Piston

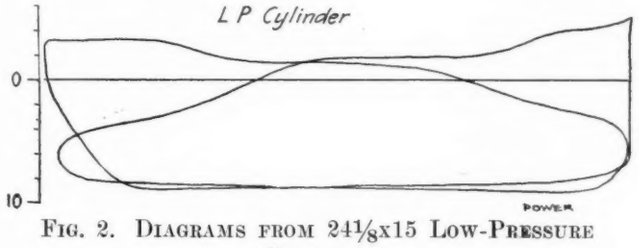


Fig. 2. Diagrams from 24⅛x15 Low-Pressure Cylinder

G. C. C. Belling.

Kinkiang, China.

Pipe Flange as Emergency Gland

I had the misfortune of breaking the gland on the steam end of a 10-ton refrigerating machine. I was alone on a night shift in charge of the boilers, generator and refrigeration system, so the repair had to be made in a hurry. I ran the machine with the gland held by one bolt until I could find a 2-in. pipe flange, which I slotted to pass over the piston rod, and placed it over the broken end of the gland. The flange required no drilling as the holes in it came in the right place for the studs in the stuffing-box.

F. E. Walchli.

Denver, Colo.

Wants Method of Cost Finding

I would like Henry D. Jackson, or some other reader of Power, to give me methods for getting at the cost per kilowatt-hour in an isolated 200-kw., alternating-current, direct-connected plant, doing its own steam heating in winter. Wages $10 for 24 hr. Coal $4.50 per ton of 2240 lb.

Ernest Milton.

Buffalo, N. Y.

INQUIRIES OF GENERAL INTEREST

Height of Lift—If a vacuum gage attached to the top of an upright suction pipe from a well indicated 22 in. vacuum during pumping, what would be the distance from the gage down to the water in the well?

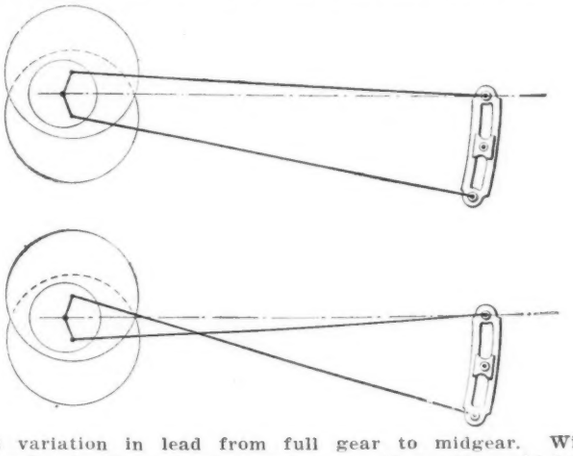
F. R. M.

If there were no friction and a tight suction pipe then 22-in. vacuum would indicate a distance of $\frac{22}{30}$ of 33.947 = 24.89 ft., but overcoming air leaks and friction due to an ordinary velocity of water in the suction pipe would reduce the figure to about 23 ft.

Link Motions—In a Stephenson link motion what are the advantages, one over the other, of open eccentric rods and crossed eccentric rods?

E. P.

The upper diagram herewith shows an open-rod link motion, the lower one a crossed-rod link motion. With open rods the lead increases and with crossed rods it decreases from full gear toward midgear. Other conditions being the same crossed rods are longer than open ones, thereby making



less variation in lead from full gear to midgear. With crossed rods, if a valve has no lap at midgear it would have lead for all other gears, whereas with open rods, if the valve has no lap at midgear it would have no lead at other gears. Hence, with crossed rods, the ports may be covered at midgear and still have lead at other gears; while, with open rods, to secure lead between midgear and full gear, the ports would have to be open at midgear, and with an open or leaky throttle, the cylinder would get steam, which under some conditions, as when engines are supposed to be standing still, is undesirable.

Collapsing Strength of Tubes—What formula will give the collapsing strength of an ordinary boiler tube? In which way is such a tube stronger, against inside or outside pressure?

J. E. M.

The formulas based upon the experiments on the collapsing strength of boiler tubes made by Prof. Reid T. Stewart for modern lap-welded bessemer steel tubes, for all lengths greater than six diameters, are as follows:

$$P = 1000\ (1 - 1 - 1600\ \frac{t^2}{d^2}) \quad \text{.....(A)}$$

$$P = 86{,}670\ \frac{t}{d} - 1386 \quad \text{.....(B)}$$

Where

P = Collapsing pressure, lb. per sq.in.;
d = Outside diameter of tube, in.;
t = Thickness of wall, in.

Formula A is for values of P less than 581 lb., or for values of the thickness of the tube divided by diameter which yield a quotient less than 0.023, while formula B is for values greater than these. In applying these formulas, in practice, a suitable factor of safety must be applied. The resistance to internal pressure is about four times as great as the collapsing strength.

Starting a Turbine—How much time is required in starting a turbine and throwing it on the switchboard? What is the procedure in starting up a turbine?

R. A. C.

Full answers to both of the above questions may be found in the prize article on turbine running printed in the August 6, 1912, issue, page 176. Turbines with small clearances and large dummy pistons must be carefully warmed when first started. Those having large clearances and of the nozzle type such as the De Laval can be started very quickly. A 5000-kw. unit has been put under way in a minute and a half. The throttle should be opened only a trifle at first and a little more at a time. All drains should be left open until the turbine is nearly up to speed. While the turbine is warming up the auxiliary machinery can be started. The turbine should be speeded up slowly except while it passes the critical speed where the tendency to vibration is a maximum. With normal speed attained and a good vacuum established, the load should be applied gradually to keep water slugs from being carried over with a sudden inrush of steam.

Inches of Pressure—What is meant by pressure in "inches of water" or "inches of mercury"?

A. A. B.

Low pressures of gases, vapors and liquids are conveniently measured by and compared to the hydrostatic pressure exerted by the head or height of liquids of known density. Measurements of such pressures are usually determined by observing the difference in height of liquid columns required to balance the difference of pressure exerted on the surface of the liquid in the branches of a U-tube; or by direct measurement of height of a single column as in a barometer, where atmospheric pressure, acting on the surface of a liquid like mercury, balances a column of the liquid in a tube, the lower open end of which is in communication with the same kind of liquid in a cup or "well," while the upper end of the tube has a sealed space which is a vacuum.

The pressure per square inch for each inch of height of column of any liquid will be the same as the weight of one cubic inch of the liquid. A pressure of 1 in. of water at 62 deg. F. = 0.03609 lb., or 0.5774 oz. per sq.in. and of 1 in. of mercury at 62 deg. F. = 0.491 lb. or 7.86 oz. per sq.in.

Hoisting-Engine Problem—What would be the horsepower of a pair of hoisting engines with cylinders 16 in. in diameter by 15 in. stroke, making 33 r.p.m., supplied with steam at 90 lb. gage and exhausting into the atmosphere? The engines are connected to a 5-ft. drum. What load could they lift?

J. E. C.

When running with full gear forward or backward, the mean effective pressure would be about 85 lb., making the horsepower

$$\frac{85 \times (16 \times 16 \times 0.7854) \times 1\frac{1}{2} \times 33 \times 4}{33{,}000} = 85.45 \text{ i.hp.}$$

With a pair of engines having cranks set at 90 deg., starting to lift a load, one crank might be on dead center, so that the starting power would depend on the force exerted by the steam on only one piston. The piston area being

$$16 \times 16 \times 0.7854 = 201.06 \text{ sq.in.,}$$

and steam pressure 90 lb. the force exerted on one piston would be

$$201.06 \times 90 = 18{,}095.4 \text{ lb.}$$

The drum being 60 in. in diameter and its radius 30 in., while the stroke of the engine is 15 in., and the crank radius 7½ in. then, without friction, one piston could start a load of

$$18{,}095.4 \times \frac{7\frac{1}{2}}{30} = 4523.8 \text{ lb.}$$

But as the net efficiency would be only about 70 per cent. the total load which the engine could be depended upon to start would be about

$$4523.8 \times 0.70 = 3166 \text{ lb.}$$

The lifting power will increase up to the point where both pistons are equally effective, and then the lifting power will be about 40 per cent. more, or about 4432 lb.

ENGINEERS' STUDY COURSE

Feed-Water Treatment

A cardinal requisite to high boiler efficiency and consequent low operating cost is a clean boiler both outside and in. The man who neglects to protect the outside of the heating surface from the accumulation of slag, soot, etc., and the inside from accumulation of scale, etc., simply because it is a bother to do so, is not living up to his opportunities.

The main sources of feed-water supply are wells, rivers, ponds, lakes, etc. The great primary sources of supply to these secondary sources are the oceans which cover about three-quarters of the earth's surface. This water contains so much impurities that it is unfit to drink or to use in a boiler until it is purified. The chief impurity is salt, the chemical name of which is sodium chloride and the chemical symbol is NaCl. The letter S could not be used in the symbol because S, you will remember, is the symbol for sulphur, so the abbreviation Na, of the Latin name *natrium,* is employed.

A gallon of sea water contains about 1.75 lb. of salt. To illustrate how difficult it would be to operate on sea water, it has been estimated that a 72-in. by 18-ft. tubular boiler (150 hp.), if it could be operated continuously at its rated capacity on sea water, would fill solid to the water line with salt in about 48 hr.

For stationary boiler plants, nature herself performs part of the purifying process. The heat of the sun causes ocean water to evaporate and rise in the atmosphere to form clouds. As salt does not vaporize at ordinary temperatures it remains behind, while only the pure water itself rises in the air. Changes in the atmospheric temperature and pressure cause the vapor to condense to the liquid form again and fall to earth as rain. Rain water is almost absolutly pure.

Water has great powers for dissolving substances. Almost everything in the world can be dissolved in it. Some substances dissolve very slowly and only in exceedingly minute quantities while other dissolve very quickly and in large quantities. In sinking into the ground or running off to the river or lake, the pure rain water dissolves substances that it happens to meet, thus becoming impure. The quantity of any given substance which the water will dissolve and carry along with it depends upon the readiness with which the substance dissolves and the length of time the water is in contact with it.

Of the many substances that may exist in a dissolved state in water, we are interested in only those which tend to cause scale, sediment and corrosion. These in themselves are quite numerous and a full study of and treatment for them all can be made only by a trained chemist. Hence, when a feed water is causing trouble it is very often advisable to submit a sample to a competent and reliable chemist or company for analysis and prescription or treatment. However, as there are a few impurities which cause the greater part of the trouble encountered, a short study of these, including an explanation of their action, how they are detected, their quantity estimated and a neutralization or elimination effected, may be worth while.

Common Impurities

The commonest impurities found in water are calcium carbonate, magnesium carbonate, calcium sulphate and magnesium sulphate—rather formidable names but really not such formidable substances, because all four of them possess only two elements that can possibly be new or strange to the students of this course. If you have forgotten what an element is, look up the first lesson of the series, Apr. 22.

Calcium Carbonate

The chemical formula for calcium carbonate is $CaCO_3$. This means that it is composed of one combining weight (see May 6 lesson) of calcium, one of carbon and three of oxygen. The calcium is the only element that is new to us. It is a metal but one which is never found in its pure or uncombined state in nature because it is a very active element and readily forms compounds with other elements. Its compounds, however, are very common substances. One of its most familiar and useful compounds is ordinary lime, such as used for making mortar and plaster. The chemical formula for this substance is CaO and its chemical name is calcium oxide. When water is added to lime, making slack lime, the formula is

$$CaO + H_2O = CaO_2H_2$$

Pure calcium can be produced artificially by reducing one of its compounds. When pure and fresh a piece of it looks like zinc. But when exposed to the air awhile it becomes yellowish and finally gray or white in color, due to a reaction between it and the oxygen and moisture of the air resulting in a layer of slaked lime (CaO_2H_2). The combining weight of calcium is 40.1 and, it will be remembered, the combining weights of carbon and oxygen are 12 and 16, respectively. Then, as its formula indicates, calcium carbonate is composed of these three elements in proportion of 40.1 lb. of calcium, 12 lb. of carbon and $3 \times 16 = 48$ lb. of oxygen. Chalk, limestone and marble are all almost pure calcium carbonate.

Pure water is capable of dissolving calcium carbonate in very small quantities—10,000 parts of water are required to dissolve one part of calcium carbonate. That is, to dissolve 1 lb. of chalk would require 10,000 lb. of water or some 1200 gal. and a peculiar fact is that calcium carbonate is less soluble in hot water than in cold. If this was the only rate at which calcium carbonate could get into a boiler (1 lb. per 10,000 of water) there would not be much difficulty in coping with it. But it is not. Carbonic acid or carbon dioxide (CO_2), our old friend which is formed when carbon is burned, can be absorbed by or dissolved in water, and in its descent through the air and travels on and in the earth water does absorb some of this gas. Now, when water containing carbon dioxide flows over chalk, limestone, rocks, marble or other substances mainly composed of calcium carbonate,

the carbon dioxide, water and calcium carbonate all get together and form a substance known as calcium bicarbonate—$CaH_2(CO_3)_2$—a substance which water can dissolve and carry in solution in quite large quantities.

This calcium bicarbonate, however, is not a very stable compound. When the water containing it is heated to 180 deg. F. or more, it begins to break up into its three components—CO_2, water and calcium carbonate. The CO_2 now changes (due to the heating of the water) into its gaseous form and, rising through the water in bubbles, escapes in the atmosphere. This leaves an excess of calcium carbonate in the water, which, as was just stated, is only slightly soluble in water. This excess, therefore, settles to the bottom as a fine powder.

When a substance is suddenly changed to its solid form and settles out of the liquid in which it was dissolved (as in the case just described) it is said to have been "precipitated" or "thrown down" and the process is called precipitation.

The foregoing paragraphs show why some boilers are found to contain internal coatings of soft sand-like or mud-like material. They have been fed with water carrying calcium bicarbonate which the heat has changed back to calcium carbonate. As the latter is a solid which cannot be vaporized (just like the sea salt) it is left in the boiler while the water which carried it evaporates and passes off as steam to the engine or other destination. Each gallon of water fed in leaves its particles of solid calcium carbonate behind and unless blown down and cleaned often enough the boiler would become choked.

This calcium carbonate by itself does not form a hard troublesome scale, but simply a loose mud-like coating which can easily be washed off the tubes and shell. In fact, a large part of it settles to the bottom of the boiler or to the mud drum of its own accord, and can easily be blown out. But, as will be seen later, when certain other impurities are present in the water, the calcium carbonate is cemented into a troublesome scale along with these other impurities.

Magnesium Carbonate

The second commonly encountered impurity in water is magnesium carbonate. Its chemical formula is $MgCO_3$. It will be noticed that the only difference between this formula and that of calcium carbonate is that Mg in the present case takes the place of Ca in the previous one. Both are carbonates, due to their carbon and oxygen content.

Magnesium is also a metal and in its pure state has a bright silvery white appearance. Like calcium it never exists pure in nature as it has very strong tendencies to combine with other elements. One of its compounds which is familiar to all is Epsom Salts. The chemical name for this compound is magnesium sulphate, which is included in our list of commonly encountered impurities and about which more will be stated later on. Other familiar substances with magnesium in their makeup are talc, asbestos and meerschaum. Magnesia pipe covering is composed principally of magnesium carbonate. The combining weight of magnesium is 24.4.

In nature, magnesium carbonate exists quite extensively and is known as magnesite. It also exists in combination with calcium carbonate, this compound being known as dolomite. Magnesium carbonate will not dissolve in pure water. But when water containing CO_2 comes in contact with it, magnesium bicarbonate—$MgH_2(CO_3)_2$—is formed and this, like the calcium bicarbonate, is quite soluble in water. When heat is applied, the bicarbonate breaks up and the CO_2 escapes as a gas, just as in the case of the calcium bicarbonate. The passing off of the CO_2 leaves behind an insoluble substance called magnesium hydroxide whose chemical formula is $Mg(OH)_2$. This precipitate being light, settles out of the water but slowly, and in the boiler where the circulation is strong it has a tendency to stay suspended and cause trouble through priming. Another bad quality of this precipitate is its cementing power, which is so great that the stuff is used for making cement for commercial purposes. When it mixes with the otherwise loose particles of precipitated calcium carbonate, a brittle scale results, which cakes on the boiler surfaces.

A Fortunately Contrary Boiler

By Carl H. Beach

A remarkable boiler came to the writer's attention not long ago in a village in Pennsylvania. It had been for 40 years in a wood-working plant where the boiler house, a light frame structure, had twice burned down around it but neither of these experiences seemed to have injured it.

Early in the summer the boiler developed a very bad leak so a boiler maker was sent for. He came, looked the boiler over and made his report which was, in effect: "I can make your boiler tight, but I cannot make it safe and my work will cost you nearly half the price of a new boiler. Your boiler is condemned and it must be at your own risk that you put pressure on it after this."

Since the boiler had held for 40 years and the previous winter carried 125 lb., whereas the usual pressure is only 75 or 80 lb. many men would have reasoned: "The Christmas trade is coming on so we can't stop now. I guess you can make it hold until we get to a more convenient time to stop." Instead, however, the plant was shut down, the old boiler was taken out and a new one put in, even though it meant an idle period of two months.

The old boiler had been dismantled so it could only be conjectured what the setting was. It was a return-tubular boiler about 4 ft. in diameter and 16 ft. long. The old tubes, most of which were apparently those originally put into the boiler, were about 3½ or 4 in. in diameter. There were, however, five tubes that had been replaced at some time, the tube sheet having been reamed out so that the space between adjacent tubes was nearly closed.

The setting was apparently of the extension front type, the front end of the boiler having been suspended from structural work resting on the side walls of the setting. The rear end of the boiler had rested on a brick pedestal in the combustion chamber. The boiler shell where it rested on this pedestal, had been very badly burned so that a hole nearly as large as a manhole had been cut to remove the damaged plate and a patch had been riveted on. The pedestal was then moved forward so as not to bear on the patch and the burning, cutting and patching were repeated, the two holes being separated by about 5 in. of whole plate. Both of these patches were well fitted and fastened in a good workmanlike manner. How the pedestal was placed after the second patch was applied

was not related, but, however it was, the difficulties already experienced only became more widespread. The bottom sheet, including both patches, was very badly burned and had started to bag. The heads of most of the rivets on the patches were burned off and the edges of the plates were so badly burned that there were cracks from the edge of the plate to the rivet hole in nearly every case.

Inside of the boiler the conditions were fully as bad as they were outside at the patched places. There was a handhole at each end below the tubes and by looking through the boiler one could see what appeared to be a heavy coating of scale all over the bottom of the boiler and the tubes that were visible through the handholes. The blowoff pipe entered the front head just below the handhole. Just in front of the blowoff pipe and directly over the fire was a pile of mud and scale fully 2 in. thick that had not been disturbed while the boiler was being rolled some 200 ft. into a field. There is no telling how thick this deposit may have been when the boiler was in service, but it was certainly no thinner.

Above the tubes conditions were not quite as bad as they were below, but even there they were bad enough to make a man think twice before attempting repairs. The heads were braced with diagonal stays of round iron. These stays and the tubes appeared to be badly corroded.

The steam dome was the most interesting part above the tubes. It was about 24 in. in diameter and 30 in. high. The top was flat and braced with round braces similar to those used on the boiler heads. How the braces in the dome were arranged or fastened was not investigated, but that is immaterial, since every one of them had broken, thus allowing the head of the dome to bow outward as though it had been dished in the mill.

Last winter trouble was experienced in keeping up steam when a young man who applied for work was given the job of firing. One day the manager went into the boiler house and found the steam gage showing 125 lb. and the safety valve, which usually blew at 80 lb., as tight as a drum. It was a lever-safety valve and had been held down by adding weights. This was remedied and the boiler was continued in service for several months, or until it developed a leak and the boiler maker was called.

In thinking the matter over one wonders how it happened that the shell at the rear of the boiler was so badly burned and the sheets directly over the fire showed no signs of overheating. Evidently, the explanation is this. The fuel was mill refuse with a little coal mixed in when this proved insufficient. The firebox was probably too low to hold a sufficient quantity of this light fuel, so it was probably crammed full and the fire-doors left open to give draft. This would drive the flame back into the combustion chamber and make it strike directly on the pedestal which must have become very hot and thus concentrated the heat on a comparatively small piece of the shell. Cramming the fuel into the furnace did not leave room for the development of a very high temperature at that point and the boiler shell over the furnace was therefore not burned.

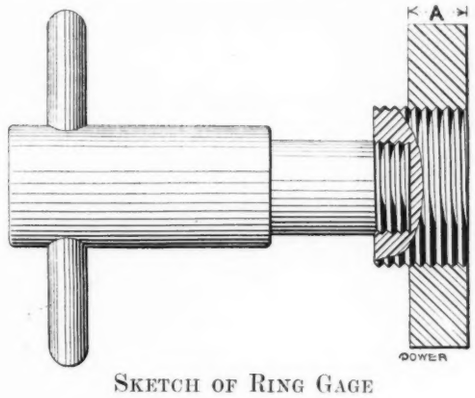
The writer has never seen a boiler that showed signs of distress more plainly nor that had been more abused. The abuse was probably more on account of ignorance of how a boiler should be used than on account of willful neglect.

Application of Briggs Pipe-Thread Gage

On Sept. 17, 1913, the Manufacturers' Standardization Committee adopted officially the Briggs pipe-thread gage for standard and extra-heavy pipe, the resolution presented reading as follows:

"Resolved: That the table and tolerance submitted be approved and that there be deposited with the Bureau of Standards at Washington, D. C., a set of gages to be known as the American Briggs Standard for Pipe Threads."

The gages consist of one plug and one ring gage of each size. The plug gage is to be the Briggs standard pipe thread as adopted by the manufacturers of pipe fittings and valves and recommended by the American Society of Mechanical Engineers in 1886. The plug is to have a flat or notch indicating the distance that the plug shall enter the ring by hand.



SKETCH OF RING GAGE

The ring gage is to be known as the American Briggs standard adopted by the Manufacturers' Standardization Committee in 1913, and recommended by the Pratt & Whitney Co.

THICKNESS ADOPTED FOR RING GAGE

Pipe Size, in.	Adopted Thickness of Ring Gage "A"
⅛	0.180
¼	0.200
⅜	0.240
½	0.320
¾	0.339
1	0.400
1¼	0.420
1½	0.420
2	0.436
2½	0.682
3	0.766
3½	0.821
4	0.844
4½	0.875
5	0.937
6	0.958
7	1.000
8	1.063
9	1.130
10	1.210
12	1.360
14	1.562
15	1.687
16	1.812
18	2.000
20	2.125
22	2.250
24	2.375

In the accompaying table the dimensions are those of the dimension *A* shown in the sketch, and are the figures adopted by the Manufacturers' Standardization Committee. In the use of the plug gage, the notch on the plug is to gage, and one thread large or one thread small is to be the inspection limits. In the use of the ring gage, male threads are to gage when flush with the small end of the ring, and one thread large or one thread small is to be the inspection limits.

Refractories for the Modern Boiler Plant*

SYNOPSIS—Conditions to be met by firebrick in actual service, kinds of brick and their composition. Increasing the life of furnace arches and a few structural details of firebrick setting.

The use of firebrick is, of course, in lining the side walls of the firebox, in constructing the firebox arch, and coking arch, where such is in use, and in the various forms of baffle tile, to direct and deflect the flames and heated gases.

In the side walls, the brick are subjected to not only the heat of the coal bed, but particularly to the action of the clinker, its tendency to fuse and flux the brickwork and the very severe abrasion of the poker and slice bar as the clinker is removed. The severity of this action is dependent on the coal, the analysis of its ash, the method of firing, draft and numerous other details in connection with its operation.

The arch, however, is subjected to rather different and even more severe conditions. Under the arch, combustion is nearly, if not wholly, complete, and the temperature will be correspondingly higher. Its under side is furthermore continually in the current of a stream of incandescent gases at high velocity, and laden with particles of fuel and ash. Often insufficient opportunity is afforded for radiation and the brick are subjected to such a temperature as makes their life at best a short one. By no means last in importance, however, is the influence of rapid changes in temperature conditions affecting both the side walls and arches, but the latter especially. This may be brought about by opening the firebox doors in firing or cleaning fires, thus allowing cold air to strike the incandescent walls and arch; by opening wide the ash doors when cleaning clinker from the grates in many forms of stoker; or from any procedure which suddenly chills or raises the temperature, even if but locally.

Materials Available

In considering the materials available for this work fire-clay brick, silica brick and bauxite brick have been taken as the only ones which, at present, give promise of being successful on any large scale. Both magnesia and chrome brick spawl far too readily if subjected to a draft of cold air. Because of the fact that the one is highly basic and the other neutral their use has been tried along the clinker line to overcome the trouble due to the adherence of this slag, and while entirely satisfactory on this score, they have been found unsuited for the reason indicated.

Fire-Clay Brick

All fire-clay brick are essentially silicates of alumina and expressed in the lowest terms, are composed of the two varieties of clay, namely, the hard, flint or block clay, as it is often termed, which forms the real body of the heat-resisting material, and the soft or plastic clay, acting as the bond to give physical strength to the brick. As conditions may warrant, a larger or smaller portion of the hard clay may be calcined previous to its manufacture into brick. Upon the character of these clays, the fineness to which they are ground, and the degree of burn given them, depend the character of the brick. In general a fine-ground, hard-burned brick gives superior results in the side walls and a more porous, open, and if it may be so termed, "elastic," brick does better in the arches.

Silica Brick

These are made from crushed ganister rock, with 2 per cent. of lime added, in the form of milk of lime, while the stone is being ground in the wet pan. Analysis of the burned brick will show an average of 1.75 per cent. in lime. A typical analysis is given in Table 1.

TABLE 1. APPROXIMATE ANALYSIS OF SILICA BRICK

	Per cent.
SiO_2	96.25
Al_2O_3	0.85
Fe_2O_3	0.82
CaO	1.80
Mg	0.15
K_2O / Na_2O	0.40
	100.27

Bauxite Brick

As the name indicates, bauxite bricks are made from bauxite ore, a hydrous oxide of alumina containing about 30 per cent. of water, practically all of which is water of crystallization. A fairly representative analysis is given in Table 2. It is mined in this country, in Georgia, Arkansas, Alabama and Tennessee, Arkansas being by far the largest producer. Large quantities are also imported from France. It is hardly necessary to say that the bulk of these various ores is consumed in the production of metallic aluminum, of the various alum salts and of abrasives. Bauxite is exceedingly variable in its composition, and great care is necessary in the selection of the raw ore for the manufacture of refractories and the maintenance of their uniformity.

TABLE 2. BAUXITE ORE

	Per cent.
Fe_2O_3	3 to 6
Al_2O_3	55 to 60
SiO_2	4 to 7
FiO_2	2 to 2.75
H_2O (Water of Crystal)	30
Moisture	1.50

The ore must be thoroughly calcined at high temperature to thoroughly remove the water of crystallization and so reduce the shrinkage; suitable bonding clays are then added and the brick are burned at the highest temperature of the kilns.

The original troubles in the use of bauxite brick were in a great measure due, not only to deficiencies in the bonding material, but to insufficient calcination of the raw stock, and the attempt to burn at too low temperatures. A high-grade bauxite brick should run as high as, say, 56 per cent. in alumina, a fairly representative analysis being given in Table 3. It can, however, be manufactured with a still higher content of alumina where conditions warrant. The term bauxite as applied to brick is, however, used so loosely that little meaning is conveyed unless at least the approximate analysis is known; many of these brick will show on a determination only from 43 to 51 per cent. in alumina. If prop-

*From a paper read by Kenneth Seaver, on June 3, before the Mechanical Section of the Engineers' Society of Western Pennsylvania, pages 339 to 353 of the July "Proceedings."

erly made, the brick is physically strong and tough, but with somewhat of a tendency to spawl in arches if suddenly cooled or heated.

TABLE 3. BAUXITE BRICK

	Per cent.
SiO_2	38.38
Al_2O_3	56.77
Fe_2O_3	2.95
CaO	0.00
MgO	1.09
Alkalies	0.88

Maintenance of Furnace Arch

In the general development of boilers, a development which has necessitated ever increasing initial temperatures, the general trend has been toward increasing the size of the combustion chamber and the location of the area of complete combustion further from the tubes. The increasing use of the Dutch oven, with its coking arch, and often the combustion arch, is an example in point; so intense is the heat developed that in certain types it has been found absolutely impossible to maintain an arch and the combustion arch has of necessity been discarded entirely. For illustration, certain definite examples will be given.

Fig. 1 shows the sectional elevation of a boiler arch and firebox where serious trouble was occurring in the combustion arch. The brick would spawl, cracking away and dropping from the under surface of the arch in chunks, so that, although the coking arch was unaffected, the combustion arch lasted but two to three weeks. The entire boiler was apparently encased in a steel shell so that the suggestion that the spawling was due in some way to admission of cold air, even with all doors above the firebox level closed, was received with ridicule.

The boiler was, however, shut down, and an inspection of the interior disclosed the following: At *XX* openings had been provided so that the induced draft from the stack would draw cold air from the sheet-iron box covering the coking arch, this casing being provided with slots at the side to cool the suspended coking arch. What was entirely overlooked, however, was the fact that this draft of cold air came directly in contact with the incandescent surface, the under side of the combustion arch. These openings were closed to keep the cold air from the inner arch, thus allowing it to radiate away its heat, and today the life of the brickwork is entirely satisfactory from every point of view.

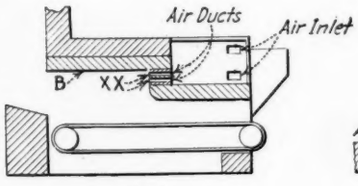
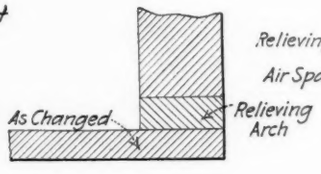
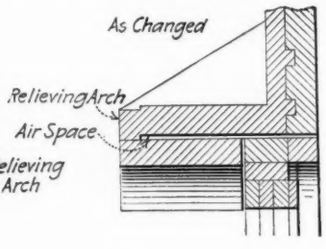
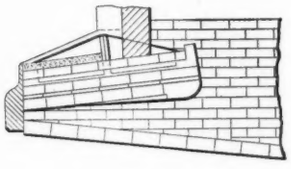


FIG. 1







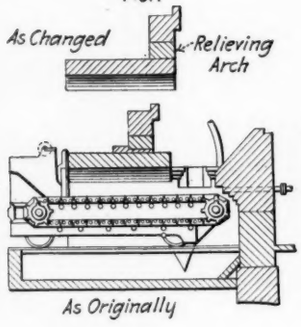


FIG. 2

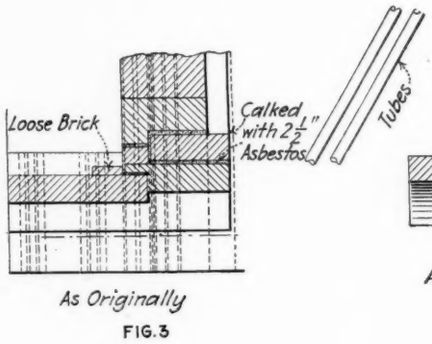


FIG. 3

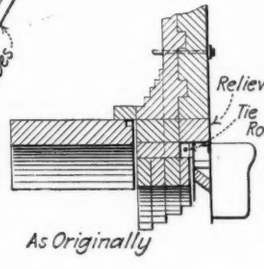


FIG. 4

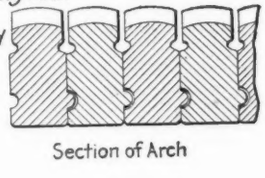


FIG. 5

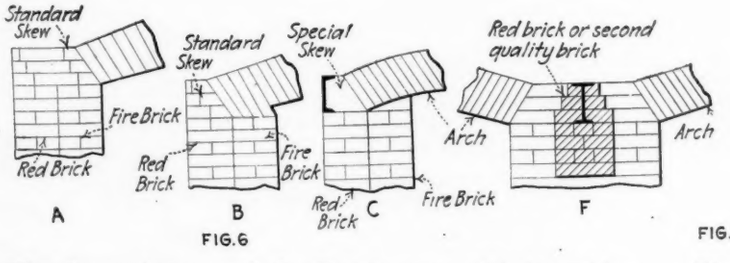


FIG. 6

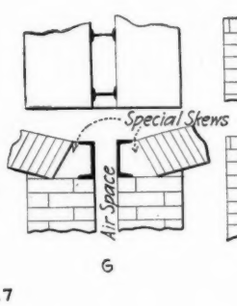


FIG. 7

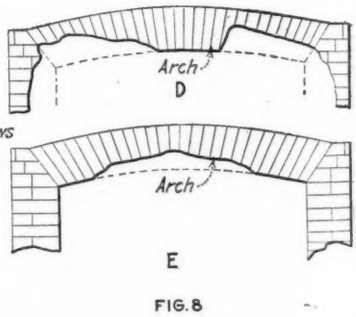


FIG. 8

Fig. 2 shows an installation, the arch of which gave much trouble as originally installed. The diagram indicates one of the familiar types of chain-grate stokers, and this sectional elevation shows the arch, front wall and bridge-wall of the boiler. A portion of the arch extends beyond the front wall, toward the bridge-wall, this extension being 22½ in. directly in the travel of the flame and so located that it was, on three sides, subjected to intense heat, while on the fourth there was little chance for radiation. Furthermore, this arch was rather flat, having a rise of but 7½ in. in 9 ft. 9 in. span.

In the two boilers of this installation the one arch collapsed after two weeks' service, the other after two days. An examination showed what had occurred. The

brick had simply softened and squeezed out of shape, allowing the collapse. The cause was simply the intense heat upon the brickwork without an opportunity for radiation. This was further emphasized by the collection of ash and soot on the upper surface of the arch, which still further insulated it, and by the pressure of the front wall.

The remedy for the situation is shown in the upper portion of this figure. A relieving arch is thrown over the inner end of the combustion arch and the interior front wall of the boiler moved forward at that point to correspond. As rebuilt the arch is giving excellent service, 9 to 15 months, with the same brick as originally installed.

Fig. 3 will illustrate still further a somewhat similar trouble, the lower portion of the sketch being the original installation and the upper portion, as revised. Here is shown a type of split arch. It has its outer end not only subjected to heat on all sides, but the spaces between the combustion arch and the relieving arches calked with asbestos, as is the case in several other instances, as will be noted. In this case not only did the inner combustion arch tend to soften and so collapse, but it pulled forward from the front wall and main portion of the arch and fell forward into the firebox. In three successive installations the arch lasted two days, eight days and nine days, respectively.

The remedy is clearly shown in the upper portion of the sketch. The split arch was done away with, making it a part of the main arch and bonded with it, a relieving arch thrown in directly over it, with all asbestos omitted and the front wall moved forward to the face of the arch. This construction is now averaging six to seven months per arch where there occur exaggerated peak loads and nine to ten months where the boilers are operated at a more uniform rate. All the above installations have one brand of brick and this type of construction has since been adopted by these engineers as standard.

In Fig. 4 is illustrated still another case. As before, the original construction is shown in the lower portion of the plate with the relative position of the boiler tubes. This is typical of three separate plants in mind, one of which gets about 40 days' life, another only about 13, while in the third arches have fallen in from five to six days. At all of these plants they have tried literally dozens of brands of brick with little difference in results.

It is here obviously impossible to move the front wall forward, but the sketch will show the change that has made possible a life of three to six months and in some cases more. It will be seen here that there is a chance for some cooling of the arch, which has none but its own dead weight to carry, and there is no chance for the collecting of ash, soot, etc., on its upper surface, or if such does collect it can be easily removed by a bar through a slot in the furnace wall.

In Fig. 5 is shown one of the typical suspended flat arches. The question is sometimes asked as to the tendency to spawling that is sometimes evident. The flat arch, of course, depends solely for its support on its suspension on metal of some form and often air cooled; the upper surface is cold, the lower hot. In the making of shapes of the size of these blocks the grind and burn must of necessity be such as will make a very much denser brick than is the case with the smaller standard sizes and a brick that will consequently tend more easily to spawl or separate. When this occurs, as it may, for instance, almost in the center of the block, the lower half drops out, while in the sprung arch there is, of course, still the curvature of the arch to hold it in place.

Another common cause of trouble found in various kinds of inclined-grate stoker arches is that of spawling during cleaning of the fires and removal of clinker. Doors are left wide open, masses of clinker sometimes two or three square feet in area may come away and with the ashpit doors wide open a blast of air goes through the grate unheated and strikes the hot brick arch. One can hear the brick snap and spawl and see the clinker drop away.

To summarize, the two main causes of arch trouble are the inrush of cold air and failure to provide for sufficient radiation. A condition illustrating this latter point is the familiar heating furnace in the rolling mill. The bridge-wall without opportunity for radiation may often have to be rebuilt every week or two, while the side walls and roof of the same furnace may last for months.

Structural Details of Firebrick Setting

In Fig. 6 is shown three methods of setting the skew back at *A*, *B* and *C*. That shown at *A* is probably the most common, but has the defect that it is difficult to repair the side walls independently of the arch. One way of avoiding this is shown at *B*, where the spring line is carried to the back wall, using 13½-in. shapes cut to fit until the inner line of the firebox is reached. The same method practically is indicated at *C*, but here a channel is used with special skews. It is evident that the inner wall can be renewed as it is burned or worn away without disturbing the arch.

In Fig. 7 is seen at *F* a type of construction more often used than would be imagined. The I-beam is inserted so that repairs to one arch may be made independently of the other, and the solid partition wall between boilers is still commoner.

It is evident here that there is no chance for radiation, and not only does the center wall tend to soften, allowing the arch to settle, but the beam in many instances has simply burned as a sustaining member. In a number of instances the inner portion of the wall has been constructed of red brick, which later became practically molten, and the entire side wall simply floated into the firebox. A good suggestion is given in *G*, where the wall is split, allowed to cool somewhat by radiation and so much increases the life of both walls and arches as to far more than offset the value of the slight heat losses.

In Fig. 8 at *D* and *E* are shown some typical arches over stokers. The contour of the burned surface indicates the influence of the draft very clearly, and it has so far proven difficult to prevent this channeling.

To consider the influence on the life of the setting of many practices fairly common among masons, the often repeated question might be cited as to whether or not the introduction of a small proportion of lime to the fire clay, thus making it easier to work, harms the setting. There can be cited doubtless thousands of cases where 1.25 to 2 per cent., or even more, lime has been used and the brick apparently remain uninjured, but

where the boiler is hard pushed, it is an element of danger, despite the fact that in many handbooks the use is not only countenanced but recommended.

In a certain boiler of a battery 1.25 per cent. lime was added to the fire clay, to the others none. The arch with the lime stood but a few days when the lime supply fused with the clay to a viscous mass and the brick merely slid from place at a temperature at which the brick themselves were absolutely unaffected. It is not the intention that the brick shall be stuck in place, but the fire clay is merely to fill the slight inequalities and interstices between the brick. They should preferably be dipped and rubbed to place.

When the manufacturer of a high-grade brick begins to insist that it should be laid with a clay corresponding in refractoriness, his motives are not invariably looked upon as altruistic, but this case shows clearly the effect of a comparatively low-grade plastic clay, but yet a fire clay, upon a refractory brick when the temperature is brought well up. Such an action is an everyday occurrence in many plants, and yet the buyer fails to account for the short life from an expensive brick.

Silica brick, more refractory than a clay brick, expand and tend to hold the arch tight and are good, strong brick physically. The great defect, however, is their tendency to spawl, and in the average boiler practice of today they are out of the question because of operating conditions.

In one large central-station plant silica arches were installed and operated with every care, and the management was carefully advised as to the necessities of the case. The life of clay brick had been six months, while the silica gave nearly eighteen months, as constant caution was necessary in firing. There are a number of plants using silica arches, but they are where uniform conditions prevail.

As to the use of bauxite brick for boiler work, although detailed and accurate data are yet hardly available, there are sufficient on which to base the prediction that its use will become general where conditions are severe. Crecelius, of the Cleveland Railway Co., published the preliminary results of his tests in which he showed the apparent absorption of silica by the clinker of the coal and the resistance to such absorption offered by bauxite.

The results show conclusively that bauxite brick are far superior in the particular practice at this plant and indicate that experimenting along these lines is well worth a trial. Its use in the fireboxes of kilns under severe service shows probably treble that of firebrick, but the data are as yet incomplete, nor have the tests in some ten or fifteen power plants yet been sufficiently long under fire to form adequate returns for basing judgment.

Kentucky Breaks Coal Record—The production of coal in Kentucky established a new record in 1912 with a total production of 16,490,521 short tons, according to Edward W. Parker, coal statistician of the United States Geological Survey. This large output represented an increase of 2,440,818 tons over the figures for 1911, and of nearly 2,000,000 tons over the former maximum output of 1910. The increased production was due chiefly to the new developments in the eastern part of the state. The number of men employed in the mines in 1912 was 24,304, and the average production per man, 678 tons. Kentucky ranks second among the states in the percentage of coal produced by machines, Ohio holding first place. Kentucky is the only one of the coal-producing states which has within its borders two of the distinctly separate great coal fields.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

All in all, this week has been both busy and versatile. We have had the Athletics and the Giants doing battle, Sulzer has had the time of his life, the Episcopalians were in convention, and Yom Kippur (the Day of Atonement) wound up the week. In between, the makers of heat and power kept things moving in a busy burg where things move every minute of the 24 hours.

The steamer "Rochelle" bumped into a school of "electric" fish off the Gulf Stream and became short-circuited, according to the "Rochelle" salts (meaning sailors). Sounds kind of fishy, though coming from Boston perhaps some fisherman is only codding.

Why not set Colonel Goethals and his splendidly efficient staff to building an Alaskan railroad? queries "Collier's." This is a good hunch. After his great work on the Canal we don't believe there's much in Alaska that would stop him from earning added laurels.

William Flewellyn Saunders flew well in our midst recently with a letter saying that the Saint Looey Business Men's League is tickled that its home town "gets the Alaska seal catch." "Flewey" is mixing us up with a skin paper. "The seal has a romantic history," we admit, but Romance can't come in if we see her first. As for sealskin— The Missis will take another season out of "something nobby, $19.98," and Goldstein will put a new velvet collar on ours.

"In the main building we have a 100-hp. coreless engine," wrote an unmechanical treasurer of a machinery company. First day we have off, we're going to give it a look.

A newspaper says this happened in a tomato-pulp plant. Just think, if this had occurred in an egg plant!

"An explosion took place at the tomato pulp plant of Williams Bros. Monday afternoon. A mud hole that connects the boiler with the reservoir gave way, blowing the fire out upon the ground. Charles Ankenbrandt was burned in the back and Ed. Mallett scalded on the arms by escaping steam. The plant will be closed for a few days for repairs."

We have a sneaking sorrow, though, for Charley Ankenbrandt and Ed. Mallet getting burned as they did.

Occasionally, "the man above the dollar" looms large. Thomas Toshesky was entombed eight days in a Lehigh Valley Coal Co.'s mine. Business was stopped while hundreds worked day and night tunneling through 52 ft. of coal. "I thank the good God for the new life!" said Thomas Toshesky, and doubtless he included the company and his fellows as well.

Marcus A. Dow, the New York Central's safety agent, says we inspect our hogs, protect our forests, conserve the nation's health and life, but—we don't keep our kids off the railroad tracks! And 5284 trespassers were killed last year by the railroads! Guess we'll have to look into this.

"In Japan it costs each person of its 52,000,000 people an average of $23 a year to live," says "Silent Partner." It must be that twenty-three which incites the little yellow man to skiddoo—and skid quick.

"Two drummers on a train," says the actress, Helen Lowell, "argued over the vacuum brake's action. It's the inflation of the tube that stops the train," declared the first.

"Wrong," shouted the second. "It's the output of the exhaustion."

When the train arrived at the station, they agreed to submit the matter to the engineer. That gentleman, leaning condescendingly from his cab, listened with an attentive frown to the two travelers' statements. Then he smiled and said:

"Well, gents, ye're both wrong, yet it's very simple. When we want to stop the train we just turn this valve and then we fill the pipe with vacuum."

Reclaiming Fuel from Chain-Grate Stokers

By Everard Brown

SYNOPSIS—By installing reclaiming plates under the chain-grate stokers from 2 to 10 per cent. of the coal was reclaimed. The heat value of this coal was less, however, than that of the fresh fuel.

In the operation of chain-grate stokers there is always a certain amount of fuel lost, due to some of the finer particles sifting down through the bars or links of the stoker and dropping into the ashpit. To a greater or less extent this is true of every make of this type of stoker in spite of all arguments to the contrary.

TABLE I. TEST ON RECLAIMING OF COAL FROM CHAIN GRATE STOKERS

	Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5
Length of stoker	10′ 2½″	10′ 2½″	10′ 2½″	10′ 2½″	10′ 2½″
Width of stokers	9′ 4″	9′ 4″	9′ 4″	9′ 4″	9′ 4″
Length of reclaiming plates	5′ 6″	6′ 6″	6′ 6″	7′ 6″	7′ 6″
Width of reclaiming plates	9′ 4″	9′ 4″	9′ 4″	9′ 4″	9′ 4″
Speed of grate, feet per hour	15 to 18	10 to 16	12 to 16	12 to 15	12 to 15
Condition of coal fired	Wet	Dry	Dry	Moist	Dry
Maximum size of coal fired	2″	2″	2″	2″	2″
Thickness of fire	4″	3½″	3½″	5½″	4½″
Pounds of coal fired	20,480	19,800	19,600	23,630	16,900
Pounds of fuel reclaimed	559	1,962	1,156	936	671
Percentage of total fuel reclaimed	2.73	9.91	5.90	3.96	3.97
Time required for handling reclaimed fuel	17 min.	32 min.	25 min.	14 min.	13 min.

The percentage of the fuel lost in this way depends, of course, upon several things, such as the speed at which the stoker operates; the condition of the coal, whether wet or dry; the thickness of fire carried and the character of the coal as regards fineness, etc. The design of the grate links is also a factor.

In order to determine just how much this loss actually is, a number of tests—results of which are given in the accompanying tables—were made under actual working conditions. No attempt whatever was made to deviate from the regular practice in operating or to do anything that would affect the results one way or the other. The tests were conducted on separate boilers of the B. & W. type, equipped with chain-grate stokers of a well known make.

Under each of these stokers and secured to the frames thereof, reclaiming or recovering plates were installed, varying somewhat in length, so as to get an idea of which would give the best results. Each plate, however, was of the same width as the stoker under which it was placed. These plates were, of course, placed under the front end of the machines.

TABLE II. PROXIMATE ANALYSIS OF COAL FIRED

	Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5
Volatile matter	36.00	35.05	34.85	35.90	35.07
Fixed carbon	51.23	50.90	51.72	50.91	51.67
Ash	12.77	14.05	13.43	13.19	13.26
Moisture	10.70	6.50	6.70	7.32	6.00

Because of running these tests under actual working conditions there were a few variables to be contended with, the most important of which probably was the variation in the speed of the stoker. It being rather difficult to accurately time the periods of change in speed, a record was made only of the maximum and minimum speeds. An average of these two would, however, give about the average speed for the full time of the test. Another variable, but not so great, was the character of the coal, it being anywhere from 2 ft. in size down to a fine dust.

The duration of the tests does not enter into consideration because the information desired and obtained is comparable with the amount of coal fired and not with the length of the tests, size of boilers or amount of evaporation. Furthermore, no saving in dollars and cents is given, as this item depends entirely upon the local conditions and, therefore, would be of no comparative value. A record was kept, however, of the time required for handling the fuel reclaimed by the plates and this is given in the results. This time is only for the one man in each case and covers all of the expense involved.

TABLE III. PROXIMATE ANALYSIS OF FUEL RECLAIMED

	Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5
Volatile matter	20.62	32.26	31.10	28.44	24.96
Fixed carbon	35.07	51.05	46.48	47.71	42.54
Ash	44.31	16.69	22.42	23.85	32.50
Moisture	2.56	4.59	1.70	1.90	2.39

TABLE IV. ULTIMATE ANALYSIS OF COAL FIRED

	Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5
Hydrogen	4.96	4.40	4.91	4.58	4.35
Nitrogen	1.15	1.13	1.26	1.20	1.17
Oxygen	6.80	10.31	9.73	10.22	10.10
Carbon	71.34	67.21	68.05	67.90	68.35
Sulphur	2.98	2.90	2.62	2.91	2.77
Ash	12.77	14.05	13.43	13.19	13.26
B.t.u. per lb. dry coal	12,600	11,200	11,890	11,675	11,560

Another point that should not be overlooked is the fact that the coal reclaimed does not have the same heat value as the original coal so that in calculating any savings in dollars and cents, such savings must necessarily be based upon heat units rather than weights of coal.

TABLE V. ULTIMATE ANALYSIS OF FUEL RECLAIMED

	Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5
Hydrogen	2.64	4.39	3.81	3.57	3.52
Nitrogen	1.06	1.12	1.20	1.19	1.18
Oxygen	3.67	10.82	8.32	7.30	6.40
Carbon	46.39	64.09	61.70	61.53	53.92
Sulphur	1.93	2.89	2.55	2.56	2.48
Ash	44.31	16.69	22.42	23.85	32.50
B.t.u. per lb.	7,950	10,900	10,550	10,420	9,317

TABLE VI. ANALYSIS OF ASH

	Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5
Volatile matter	1.67	1.40	1.64	3.30	0.82
Fixed carbon	10.43	13.96	8.19	22.92	10.08
Ash	87.90	84.64	90.17	73.78	89.10

A Home-Made Feed-Water Heater

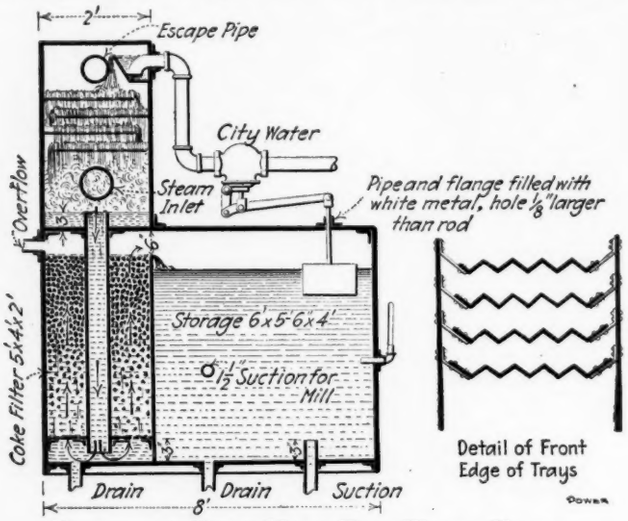
By E. R. Pearce

On taking charge of an old plant the writer was impressd with the large quantity of exhaust steam blowing to waste, in addition to the discharge from about 18 steam traps and various machines using steam for drying purposes.

Permission was granted by the owners to put in any devices that would tend to more economical running. The first thing decided on was to put in a feed-water heater of the open type to handle approximately 45,000 lb. of water per hr., a portion of which was for boiler feed, the remainder being for process work in the factory. On getting in various makers' prices, I was disappointed, as they were much higher than expected, so we turned our attention toward obtaining material with which to make the heater shown herewith.

This heater is giving an average temperature of 190 deg. F. with no steam passing out of the escape pipe. No doubt a little higher temperature might have been obtained had the water been broken up into a greater number of films. The heater did not cost one-half of the quoted prices of others and it gives entire satisfaction.

In one department alone the output has been increased 30 per cent. by their being supplied with hot water, whereas previously they received water at atmospheric temperature and had to heat it with live steam to 200 to 210 deg. F. The heater has cut down the fuel by an average of 448 lb. per hr. The boilers are now much



DETAILS OF HOME-MADE FEED-WATER HEATER

cleaner as the filter seems quite capable of keeping back all the dirt and sediment; the flow through the filter is reversed for a few minutes every evening by opening the drains and shutting the inlet valve.

NEW PUBLICATIONS

THE SCIENCE OF BURNING LIQUID FUEL. By William Newton Best. Published by W. N. Best, of 11 Broadway, New York City. Cloth; 152 pages, 6x9 in.; illustrated; indexed. Price, $2, net.

The book was written by a man whose experience in oil burning dates back to 1887, and as "engineer in caloric" is still engaged in the business. The treatment takes up the origin, production and analysis of liquid fuel, atomization, oil systems, refractory material, locomotive equipment, stationary and marine boilers, ovens and furnaces. A little over half the book is devoted to the subjects last named. Aside from the fact that many of the illustrations have suffered from too much reduction, and that they deal exclusively with the best products and methods, the book contains enough good practical information to be well worth the purchase price.

AIR COMPRESSION AND TRANSMISSION. By H. J. Thorkelson. Published by McGraw-Hill Book Co., New York City. Cloth; 200 pages, 6x9 in.; 143 illustrations; tables. Price, $2, net.

The book aims to present in logical order the fundamental principles dealing with the subject of the compression of air and its transmission. As it is made up from notes used for a number of years by the author in his classes and is thus elementary in character, it is suited for beginners. The field is well covered, as the following list of topics discussed will indicate: Fundamental definitions, thermodynamics of air compression and expansion, air at pressures below the atmosphere and at low pressures above, piston compressors, efficiencies, multistage compression, turbo and hydraulic compressors, effect of altitude, receivers, measurement and transmission of compressed air, and the selection and care of compressors. Appendices on common and Naperian logarithms and a short discussion of hygrometry make a useful addition to the text matter. The book will introduce the student to the broad field of air compression and should be of great service to the engineer wishing to know the wherefore of his compression machinery.

STEAM POWER PLANT ENGINEERING, fourth edition. By G. F. Gebhardt. Published by John Wiley & Sons, New York, 1913; 989 pages; 6x9 in.; illustrated. Price, $4 net.

Since its first appearance in 1908 this work has become to be regarded as a standard reference for practicing engineers on matters pertaining to power-plant engineering. The rapid evolution in power-plant practice and especially prime movers has made it necessary to revise a large part of the text, the chapters on Fuels and Combustion, Engines, Turbines, Condensers and Economics, having been entirely rewritten.

For those not already familiar with the book a list of the subjects covered will give an idea of its general scope; these include, Elementary Steam Power Plants, Fuels and Combustion, Boilers, Smoke Prevention, Furnaces, Stokers, Superheaters, Coal and Ash-Handling Systems, Chimneys, Mechanical Draft, Steam Engines, Steam Turbines, Condensers, Feedwater Heaters, Pumps, Piping, Lubrication, Testing and Measuring Apparatus, Cost of Power, Specifications, Typical Central Stations and Typical Isolated Plants.

The figures on power costs have been gathered from a large variety of sources and include both initial and operating costs. They show clearly the dependence of the latter upon load factor and form one of the most valuable chapters of the book.

RULES OF MANAGEMENT. By William Lodge. One hundred and thirty-nine 5x7½-in. pages. Price, $2 net. McGraw-Hill Book Co., 239 West 39th St., New York, N. Y.

This book is the outgrowth of a series of articles published in the "American Machinist," dealing with managerial and manufacturing experience. The author, William Lodge, is one of the best known machine-tool builders in the United States, and this book has been written from a lifetime of active, varied experience. Although it applies directly to the organization and management of a machine-tool factory, the principles and methods have a wider application. All the members of the executive staff and all shop departments are treated of in detail in a series of helpful rules and comments. The book should be of service to anyone having to do with machine-shop management. The scope of its pages is indicated by the 35 chapter headings, which are as follows:

The Exceptional Employee: The General Manager; Assistant Manager; Chief Engineer and Designer; Drawing Room; Purchasing Agent; Incoming Material and Storage Department; Superintendent of Manufacture; Routing Department; Chief Clerk; Cost and Timekeeping Department; Operation of Premium Plan; Superintendent of Assembly; Handling Complaints; Pattern Shop; Tool-Making Room; Forge Department; Lathe Department; Grinding Department; Drilling Department; Planer Department; Milling Department; Gear-Cutting Department; Special Manufacturing Department; Inspecting Department; Specific Instructions for Painting Lathes; Sales Manager; Shipping Clerk; Boss Laborer and Express Truckman; Millwright and Belt Man; Engineer, Electrician and Oiler; Janitors and Watchmen; A Proposed Pension Plan; Basis on which a Fund Can Be Started.

POWER PLANT TESTING. By James Ambrose Moyer, S. B., A. M.; second edition. McGraw-Hill Book Co., Inc., New York, 1913. Cloth, 486 pages, 6x9 in.; illustrated. Price, $4.

This work has passed to the second edition in two years, having been extensively adopted as a class manual by technical schools and colleges. Sixty-four pages, 120 engravings, and a number of forms and tables have been added.

The chapter on the Measurement of Pressure has been expanded to include barometers; to the treatment of pyrometers, that of electrical resistance and radiation types has been added; the treatment of the indicator has been improved by a discussion of the errors of the diagram, and directions for indicating and computing the horsepower of rotary engines; and descriptions of speed counters and tachometers have been included. A treatment of the differential dynamometer has been added to the section on transmission dynamometers, and the chapter on the measurement of power has been made to include a section on torsion or shaft dynamometers, and the accelerometer.

Pitot tube meters have been included in the steam section and weir meters in the water section of the chapter on the Flow of Fluids. The chapter on Flue Gas Analysis has been amplified by a consideration of the Hempel gas apparatus and a section upon smoke determination. The instructions regarding Reports of Tests in General from the report of the Committee on Power Tests of the American Society of Mechanical Engineers has been incorporated as an entire chapter; and their rules for producer and gas engines, as well as steam plants, incorporated in their proper connection.

A chapter upon Tests of Lubricants has been added, and a

consideration of air lifts to the chapter upon Hydraulic Machinery. The revision upon which the author places the most stress is an outline of a series of tests, arranged to suit, as nearly as possible, a large number of American technical schools. By the judicious use of these outlines, at least 50 per cent. of the time of an instructor, the author thinks, can be saved, and the efficiency of the courses will be improved.

⁂

PRACTICAL ALTERNATING CURRENTS AND ALTERNATING-CURRENT TESTING. By Charles F. Smith, fifth edition. Published by Scientific Publishing Co., Manchester, Eng., 1913. Size, 5x8 in.; 398 pages, illustrated. Price, 6s. net.

The method of presentation is unusual, the principles of alternating currents being approached from the experimental rather than the abstract theoretical standpoint. The treatment is simple yet thorough, and higher mathematics have been avoided except in the last chapter on the composition of voltage waves. Hence, the book, although intended primarily for students in technical schools, should also appeal to the practical man desiring an insight into the principles of electricity. Generally speaking, this is perhaps one of the best all-around books on the subject.

⁂

A table of estimated radiation has just been issued by Harry B. Perrigo, of 106 Hobart St., New Haven, Conn. It is printed upon two sheets of celluloid 4½x7, and gives the square feet of radiation required for glass and exposed wall surface, or cubic feet of contents. Price, $1.

⁂

"The Polytechnic Engineer"—Vol. 8 of "The Polytechnic Engineer," published annually by the students of the Polytechnic Institute of Brooklyn, has just appeared; 138 pages in size in cloth binding, and dedicated to Prof. Samuel Sheldon. In addition to institute matter, it contains a number of excellent papers upon engineering subjects.

⁂

The Babcock & Wilcox Co. was one of the first of the large manufacturing firms to realize that a catalog could advantageously be something more than a brief for its product. Its publication, "Steam," is really a textbook upon the subject, and its earlier issues are among the prized possessions of many engineers.

The latest edition, which has just appeared, is richer than its predecessors in typography, engravings and contents. Only 78 of its 335 pages are directly devoted to the product of the Babcock & Wilcox Co., if we except the illustrations of plants with which the volume is interspersed, the remaining pages dealing with such subjects as Heat and Its Measurements; Steam, with an Excellent Abridgment of the Marks-Davis Tables; Moisture in Steam; Properties of Air; Combustion; Fuel and Combustion; Boiler Tests, etc.

⁂

Annual Meeting of A. S. M. E.

The committee on meetings has arranged the following tentative program for the annual meeting of the American Society of Mechanical Engineers. A feature will be the presentation of the Grasshof medal, which was placed in the hands of the society to deliver to its past president, George Westinghouse, at the notable Leipzig meeting. Another event of interest which it is expected will be largely attended is the German dinner scheduled for Thursday evening of the meeting, at which one of the menus of the German trip will be reproduced and addresses will be given with lantern slides upon incidents of the trip.

TUESDAY EVENING, DEC. 2

President's reception.

WEDNESDAY MORNING, DEC. 3

Business meeting, followed by professional session with the following papers: "Efficiency of Rope Driving as a Means of Power Transmission," E. H. Ahara; "Comparative Tests of Lineshaft Bearings," Carl C. Thomas, E. R. Maurer, L. E. Kelso; "The Art of Enameling, or the Coating of Steel and Iron with Glass," Raymond F. Nailler; "Stability in Flying Machines," Albert A. Merrill (contributed by the New York Local Committee).

WEDNESDAY AFTERNOON

Railroad session, with papers on "Steel Freight Cars" (contributed by the subcommittee on railroads).

WEDNESDAY EVENING

Presentation by the Verein deutscher Ingenieure of the Grasshof medal to George Westinghouse, past-president and honorary member.

Arrangements are being made for a lecture to follow the ceremony of presentation.

THURSDAY MORNING, DEC. 4

Professional session, with the following papers: "Pitot Tubes for Gas Measurement," W. C. Rowse; "Tests of Vacuum Cleaning Systems," J. R. McColl; "Tests upon the Transmission of Heat in Vacuum Evaporators," E. W. Kerr; "A New Centrifugal Pump with Helicoidal Impeller," C. V. Kerr (contributed by the New York Local Committee); "A New Process of Cleaning Producer Gas," H. F. Smith (contributed by the Gas Power Section).

Arrangements are also being made for simultaneous sessions on machine-shop practice, cement manufacture, and textiles, by the subcommittees in charge of these subjects. At the machine-shop session, among the topics to be discussed are: "Use of Gears in Machine Tool Drives," "Grouping of Machine Tools," "Cast Iron for Machine Tools," "Flooded Lubrication and Force Fits." The discussion at the cement session will cover the use of powdered fuel and other subjects to be announced later. The textile session will take up cost finding and general efficiency, heating buildings through the sprinkler system, and fire escapes as applied to textile mills.

THURSDAY AFTERNOON

Excursions to points of interest in New York and vicinity.

THURSDAY EVENING

German dinner, reproducing one of the menus from the trip abroad. This will not only be a reunion of those who went on the trip, but is being arranged with a view to giving those who were unable to participate some idea of the many interesting events which the American guests enjoyed. Addresses on the German trip will be made, illustrated by lantern slides. Following the dinner a dance will probably be arranged for.

FRIDAY MORNING, DEC. 5

Session on fire protection. Among the subjects to be discussed are the management of valves controlling automatic sprinkler heads, extinguishing of fires in oils and volatile liquids, and the fire hazard in turbo-generators, contributed by the subcommittee on fire protection.

FRIDAY EVENING

College reunions. The alumni of Stevens Institute of Technology are arranging for a theater party, to which the society and their guests are invited. Supper and informal dancing at a convenient hotel will follow. The alumni of Sheffield Scientific School will arrange a similar reunion.

SOCIETY NOTES

A local association of building owners and managers has recently been formed in Buffalo, N. Y. The following offices are represented: Brisbane Building, Chamber of Commerce, Dun Building, Electric Building, Ellicott Square, Fidelity Building, Iroquois Building, Marine National Bank Building, Morgan Building, Mutual Life Building, Prudential Building, Sidway Building, Telephone Building, White Building.

OBITUARY

PAUL M. J. LIESS

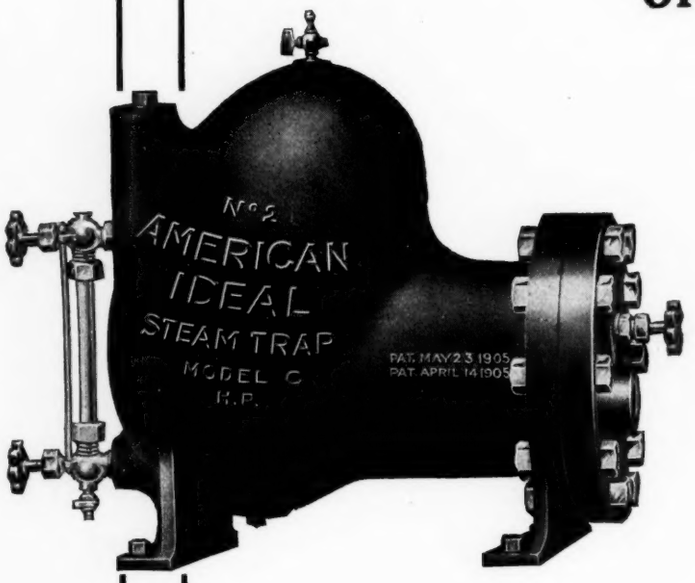
Paul M. J. Liess, chief engineer of the Long Island City power house of the Pennsylvania R.R., died at his home in Brooklyn on Oct. 8 after a long illness. Mr. Liess was 37 years of age. He was a member of the Blue Room Engineers Society.

EDWIN T. MOORE

Edwin T. Moore, secretary and treasurer of the Coatesville Boiler Works and a director and member of the executive board of the Coatesville Foundry & Machine Co., died at his home in Coatesville, Penn., Sept. 25. He was 47 years old. Mr. Moore entered the employ of the boiler works 26 years ago and in ten years became secretary and treasurer. Two years later his remarkable knowledge of all the details of the business resulted in his being made general manager. He was one of the founders of the Coatesville Foundry & Machine Co. and was prominent in Coatesville institutions.

Archimedes Said: I Could Move

We said:—"If a steam trap enough to sustain a very of meeting excessively high



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The AMERICAN IDEAL STEAM TRAP steps in and fills the bill.

Archimedes never found his fulcrum but we found the leverage necessary to place the AMERICAN IDEAL STEAM TRAP in a class by itself for working under high pressures.

The most powerful arrangement of levers found in any other steam trap is not nearly so powerful as is found in the AMERICAN IDEAL STEAM TRAP.

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